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IMPLANTATION D'UNE INDUSTRIE PETROCHIMIQUE DANS LES PAYS EN VOIE DE DEVELOPPEMENT

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IMPLANTATION D'UNE INDUSTRIE PETROCHIMIQUE DANS LES PAYS EN VOIE DE DEVELOPPEMENT

Par Clément THONON

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à l'INSTITUT FRANCAIS DU PETROLE

I - INTRODUCTION

Facile à transporter, peu coûteux, matière première aux multiples possibilités, le pétrole est à la source de l'évolution rapide de la chimie moderne.

Les produits chimiques dérivés du pétrole, produits pétrochimiques se sont développés parce qu'ils permettaient, soit d'aboutir à des prix de revient moins élevés que par les autres voies, soit de satisfaire à des besoins en matières premières qui ne pourraient être satisfaits par les sources existantes : carbochrome, distillations du bois, industrie de fermentation. Souvent ils remplissaient les deux conditions :

Ainsi l'industrie pétrochimique suscite un intérêt particulier pour les pays désireux de développer leur activité industrielle, d'accroître leur richesse et leur niveau de vie, enfin d'économiser des devises en réduisant leurs importations.

Cependant l'industrie pétrochimique est sujette à divers impératifs particuliers qui conditionnent son implantation.

Ces impératifs sont notamment liés à la capacité des installations, à leur complexité et expliquent la nécessité d'une approche d'ensemble du problème par la mise en oeuvre d'un plan d'étude détaillé qui permet de choisir la solution la meilleure dans les circonstances envisagées. Ce plan ne doit pas uniquement tenir compte des facteurs techniques, mais aussi économiques et politiques.

2 - LES ELEMENTS DE BASE

Etablir un plan d'ensemble est une nécessité qui ressort de la complexité de l'industrie pétrochimique et de ses impératifs économiques. Dans des communications précédentes, l'I.F.P. a montré l'importance de ces notions et discuté les problèmes techniques et économiques permettant de déterminer le prix de vente d'un produit, les critères de viabilité d'un projet et les conditions nécessaires pour pouvoir exporter ou échanger ces produits.

a) Problèmes techniques.

1) Complexité des fabrications.

Dans l'industrie pétrochimique, les matières premières peuvent être, entre autres, du gaz naturel, du pétrole brut, des gaz de raffinerie, des fractions ... Ces matières premières ne sont pas des composés purs, les réactions chimiques sont rarement sélectives. Il est donc très rare de faire un seul produit, presque toujours il y aura production simultanée de plusieurs sous-produits.

Pour obtenir des prix de revient intéressants pour le produit principal, il est indispensable de valoriser les sous-produits et pour cela d'en disposer en quantité suffisante. Ce qui conduit à construire un complexe intégré de capacité suffisante, groupant autour de l'unité principale toutes les unités secondaires utilisant les produits de cette fabrication. Un exemple caractéristique de complexe intégré est celui basé sur le "steam-cracking" de naphta qui, à côté du produit principal éthylène produit : du propylène, des butènes, du butadiène, une essence à caractère aromatique, un résidu et du gaz sec. La meilleure utilisation de ces produits dépendra de la taille de l'installation, mais normalement tout un complexe peut être construit, fabriquant des plastiques, des détergents ...

L'ensemble des fabrications d'un tel complexe est représenté sur la figure 1.

L'importance de la valorisation des produits secondaires est telle que le prix du produit principal peut varier du simple au double.

Toutes autres conditions identiques, une unité de steam-cracking produira l'éthylène, ou une capacité type de 50.000 T/an,à :

- 6 ct/lb - cas du complexe intégré, (valorisation éthylène + propylène, butadiène, essence)
- 8 ct/lb - valorisation éthylène + propylène
- 10 ct/lb - cas de l'unité isolée (valorisation de l'éthylène uniquement).

Et ceci ne tient pas compte de la diminution des charges générales dans le cas d'un complexe intégré qui pourrait encore augmenter cette différence.

ii) Influence de la capacité.

L'analyse de la structure des prix de revient fait apparaître qu'une partie de ce prix est fixe - c'est-à-dire indépendante de la production réelle - et liée principalement au montant des investissements et qu'une autre est variable et directement liée à la production réelle (consommation de matière première, d'utilités, ...). Les investissements ne varient pas linéairement avec la capacité, mais suivent une puissance généralement comprise entre 0,5 et 0,7 suivant les types d'installation. En conséquence la part des frais fixes sera d'autant plus élevée que la capacité sera faible.

A titre d'exemple si une unité de production de 10.000 T/an d'ammoniac coûte 2,28 millions de $, une unité de 50.000 T/an ne coûtera que 6,7 millions de $, soit environ 3 fois plus pour une augmentation de capacité de 5, augmentant ainsi de manière notable le prix de revient ainsi qu'il apparaît à la figure 2.

Bien sûr, les valeurs figurant dans ce tableau sont arbitraires et dépendront en fait principalement des conditions économiques utilisées, secondairement du prix des matières premières et des utilités, mais la tendance n'en sera pas modifiée.

b) Problèmes politiques et économiques.

Les problèmes techniques évoqués ci-dessus sont accompagnés de problèmes politiques et économiques importants. La viabilité d'un projet pétrochimique peut être modifié par les conditions économiques choisies. Les marchés des pays en voie de développement sont souvent réduits et la capacité des installations projetées faible. Un système économique rendu possible par la protection de l'Etat (taux d'intérêt faible, amortissement long, absence de taxes sur les bénéfices) permet dans certains cas de justifier la viabilité d'installation de faible capacité. En effet les charges fixes telles que mentionnées à la figure 2 peuvent passer de 68,5 à 49 en fonction du système économique, pour une production de 10.000 T/an d'ammoniac.

Néanmoins, malgré ces conditions favorables, les prix de revient sont trop souvent marginaux, sinon trop élevés. L'exportation permet en principe d'augmenter la capacité et ainsi de dépasser le "minimum économique" mais cette solution se heurte à de nombreux obstacles.

Il ne peut actuellement être question, sauf cas particuliers, d'exporter des produits pétrochimiques vers les pays hautement industrialisés d'Amérique et d'Europe. Les autres pays en voie d'industrialisation se considèrent généralement comme des cas particuliers et répugnent à importer pour diverses raisons économiques et politiques. Dernière objection, il faut rencontrer sur les marchés d'exportation la compétition des organisations de vente bien établie des grandes compagnies productrices américaines et européennes qui, disposant souvent d'unités de grande capacité déjà amorties, peuvent se permettre des réductions de prix et, en outre, disposent de services techniques importants qui leur permettent l'étude des marchés et l'assistance à la clientèle.

Par contre, il apparaît plus aisé et plus efficace de procéder entre pays voisins à des accords d'échange qui, tout en présentant les montages recherchés par l'exportation, sont assortis d'avantages mutuels qui leur permettent de se réaliser réellement. Cette solution permet d'éviter des dépenses en devises étrangères et, simultanément, de développer une industrie sur des bases économiques saines.

3 - PLAN D'ENSEMBLE NECESSAIRE A L'ETABLISSEMENT D'UNE INDUSTRIE PETROCHIMIQUE.

Etablir un plan général est une nécessité qui ressort, comme nous l'avons vu, de la complexité de l'industrie pétrochimique et de ses impératifs économiques.

Il est nécessaire que les responsables aient suffisamment d'informations à leur disposition pour prendre les décisions.

Ce n'est pas le moment d'engager des études d'engineering coûteuses à ce stade. Ce qu'il faut savoir, c'est :

- quelles installations, ou ensembles d'installations, sont viables;
- où doivent-elles être établies;
- quelles matières premières peuvent être utilisées;
- quel mode de financement sera choisi.

a) Première étape : étude générale (feasibility report)

Cette première étape comprend d'abord l'étude du marché, c'est-à-dire l'évaluation la meilleure possible des besoins actuels et futurs du pays. Compte tenu des délais de réalisation et de complexité et de l'interdépendance des productions pétrochimiques, il est nécessaire que les prévisions portent au minimum sur 5 ans ou mieux sur 10 ans. Ensuite, connaissant les besoins du marché, l'on examinera les différentes possibilités permettant de le satisfaire. Les productions pétrochimiques seront groupées en complexes les plus avantageux sur des bases technique, économique, et de disponibilités en matière première. La meilleure localisation sera déterminée. Pour chaque cas, on étudiera la rentabilité des divers produits individuellement et du complexe. En possession de ces données, l'on estimera la viabilité des divers projets.

Pour critiquer la viabilité d'un projet, il est nécessaire de disposer de points de comparaison. Etablir de tels critères est un sujet délicat qui met en cause des problèmes techniques, économiques et aussi politiques. Comme ces critères n'existent pas, les points suivants pourront utilement être considérés.

Il existe un accord général qu'il est très souhaitable de produire aux prix internationaux réels. Il est à peu près aussi général de considérer comme non viables des projets qui portent ces prix à deux ou trois fois leur montant.

Entre ces deux cas bien définis, il existe un intervalle qui prête à discussion. Nous pensons que l'on peut considérer comme règle générale (ainsi que toute règle générale, elle pourrait par ailleurs souffrir certaines exceptions) de ne produire que lorsque le prix ou lieu d'utilisation sera inférieur à 13% des prix mondiaux réels.

L'application de ce critère permettra de dégager quels sont les complexes qui seront viables.

Il est important que cette première étape soit réalisée le plus tôt possible afin d'examiner l'effet de modification que l'on pourrait apporter, par exemple le changement de localisation du complexe en un délai dans la construction de certaines parties de ce complexe. Dans le cas du "steam-cracking", on pourrait concevoir de décaler dans le temps l'utilisation du propylène. L'éthylène serait donc plus cher mais pour un temps limite.

Après cette première étape, nous disposerons donc d'un plan qui aura étudié diverses possibilités de production et aura dégagé les projets viables.

b) Seconde étape - la décision

Disposant d'un plan précisant

- l'estimation des investissements et du coût opératoire,
- la localisation et la matière première,

il faut décider ce que l'on peut raisonnablement espérer réaliser, compte tenu des conditions particulières : disponibilité de devis, licence, structure industrielle du pays, part des secteurs privé et public, et comment trouver les fonds nécessaires et les partenaires intéressés.

On établira également une éventuelle politique d'échange en sachant :

- combien il coûterait de produire soi-même si l'on choisissait de ne pas importer,
- quel prix l'on pourrait demander si l'on décidait d'exporter.

Il serait ainsi possible de négocier sérieusement sur des points précis et de conclure des accords mutuels d'approvisionnement par échange avec d'autres pays en voie d'industrialisation mais dont les possibilités pourraient être complémentaires.

A ce stade, les projets sélectionnés pourront être revus et une étude plus fouillée établie, par exemple une offre "clé en main" (turn key bid) peut être demandée à des firmes d'engineering.

c) Troisième étape

Une fois la décision et les modalités d'établissement prises, il importe de coordonner l'ensemble.

La nécessité de cette coordination est à elle seule un solide argument en faveur d'un plan général de la réalisation. De plus il ne faut pas oublier que, même approuvé, le plan peut être révisé pour tenir compte d'une disponibilité nouvelle en matière première, d'un nouveau progrès dans la technologie ou d'une demande imprévisible du marché.

4 - LE DEVELOPPEMENT DE L'INDUSTRIE PETROCHIMIQUE

Promouvoir une industrie pétrochimique dans les pays en voie d'industrialisation est un problème. Il a, dans certains cas, été réglé au hasard des contacts et en essayant de voir quel était l'intérêt des interlocuteurs en pétrochimie.

Cette voie est rarement couronnée de succès car, d'abord, on ne sait pas que faire en pétrochimie; ensuite, même si l'on avait un bon projet, l'interlocuteur n'était pas nécessairement le bon partenaire. En allant plus loin encore, même si c'était le bon partenaire, il était encore nécessaire de connaître approximativement sur quelles bases on allait traiter.

a) pourcentage de capital étranger et local, de secteur public ou privé;

b) ce qui est considéré comme une rentabilité raisonnable des investissements;

c) politique de rapatriement du capital et des dividendes;

d) politique éventuelle d'exemption de taxes.

Il est assez difficile d'obtenir, dans un pays, un accord général sur tous les points à moins qu'il ne s'agisse d'un projet précis, à un endroit précis, et avec un partenaire précis. Et si, finalement, le projet se réalise, trop souvent, la rentabilité est faible et chaque partenaire se sent frustré.

La situation est bien différente dans un pays si, non seulement, il existe un plan général tel que nous l'avons démontré, mais encore une organisation bien au courant de la situation dans le domaine des affaires chimiques internationales, et qui connaisse :

- quels sont les prix réels;
- quels sont les procédés à installer actuellement;
- quelles sont les conditions de redevances, de know-how, de participations qui sont généralement offertes aujourd'hui;

Ceci ne peut d'ailleurs que très rarement et très partiellement être obtenu dans la littérature.

Afin de préciser quelle peut être l'avantage de cette situation, nous présentons un exemplaire hypothétique où l'on disposerait des éléments suivants :

a) Une unité de 50.000 T/an d'éthylène pour polymérisation est projetée à A.
b) Une unité de polymérisation de 25.000 T/an minimum, mais pouvant atteindre 40.000 T/an est projetée.
c) Le prix de revient de l'éthylène serait de 5 cts/lb.
d) On cherche un partenaire qui aurait entre 30 et 49 % du capital.
e) Le capital pourrait être rapatrié à raison de x % maximum.
f) Une rentabilité de z % après taxe est acceptable.
g) Les firmes compétentes sur un plan international dans ce domaine et pouvant constituer un partenaire convenable sont A, B, C, ... dans tel ou tel pays.
h) Les investissements, frais opératoires, redevances, "know-how", sont de ...

Dans ces conditions, il est réellement possible de contacter les meilleurs partenaires et de voir quels sont ceux qui seraient intéressés.

Cette méthode dynamique d'approche a en outre l'avantage d'apporter une base concrète de discussion, de juger quelle est la meilleure offre, de soupeser l'avantage qu'il y aurait à traiter avec une autre firme, qui se présenterait avec peut-être moins de renom international mais avec une proposition plus avantageuse et des garanties suffisantes.

CONCLUSIONS

L'industrie pétrochimique est sujette à divers impératifs qui conditionnent son implantation. Ces impératifs sont notamment liés à la capacité des installations, à leur complexité et rendent nécessaire une approche d'ensemble du problème par la mise en oeuvre d'un plan d'étude détaillé.

Ce plan doit tenir compte des facteurs techniques et aussi des facteurs économiques et politiques.

Ce plan comporte normalement trois étapes :

- étude générale (feasibility report),
- la décision,
- la coordination et la réalisation.

Il ne peut pas être statique et doit être revisé pour tenir compte d'éléments nouveaux : modification des disponibilités en matières premières, progrès dans la technologie, demande imprévisible du marché.

Cette méthode dynamique d'approche du problème de l'implantation pétrochimique permet le développement harmonieux et accéléré de cette industrie, et évite que par des décisions partielles et dispersées l'on obère le futur.

ELEMENTS DU PRIX DE REVIENT

	10.000 T/an d'ammoniac	50.000 T/an d'ammoniac
Frais fixes liés à l'investissement	51 %	39 %
Frais opératoires	39 %	45 %
Coût de la matière première	10 %	16 %
	100 %	100 %
100 % =	107 $/T	67 $/T

ELEMENTS DU PRIX DE VENTE

	10.000 T/an d'ammoniac		50.000 T/an d'ammoniac	
Frais fixes liés à l'investissement	33 % + 35,5 %	68,5 %	28 % + 29 %	57 %
Bénéfice et taxes*				
Frais opératoires	25 %		32 %	
Coût de la matière première	6,5 %		11 %	
	100 %		100 %	
100 % =	166 $/T		95 $/T	

* "Pay-out" 5 ans après taxe
Taxe de 50 % sur le bénéfice brut

Tableau 2

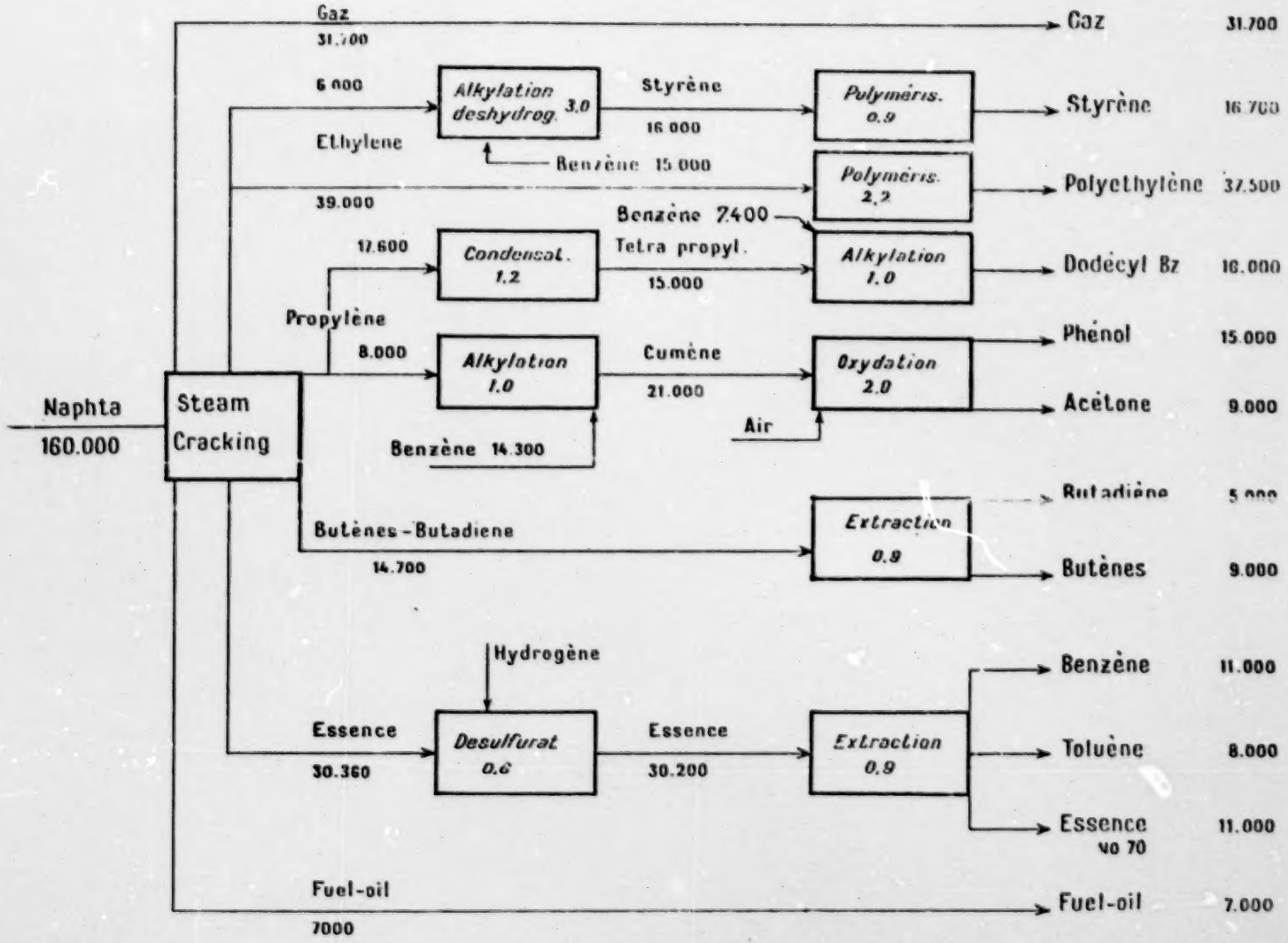

Fig.1 _ Schema de principe d'un complexe petrochimique.

Nota : Les chiffres dans les cartouches indiquent les investissements en millions de Dollars
Les autres donnent les quantités en tonnes.

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SUMMARY

Agenda Item: D.12

France

ESTABLISHMENT OF A PETROCHEMICAL INDUSTRY IN THE DEVELOPMENT COUNTRIES

By Clément THONON,
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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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No. 1299

ESTABLISMENT OF A PETROCHEMICAL INDUSTRY IN THE DEVELOPMENT COUNTRIES

D.12

By
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SUMMARY

Inexpensive and easy to transport, a raw material with many possibilities, petroleum is the origin of the rapid evolution of modern chemistry; thus, petrochemistry is of particular interest to those countries desirous of developing their industrial activity, increasing their wealth and standard of living, finally of conserving their foreign currency resources by reducing imports.

Neverthless, the petrochemical industry is governed by various particular factors which condition its establishment.

One of the most important factors is the determination of suitable economic size for the installation. This must not be lower than a certain value called the "minimum economic size", below which the cost price of the product is higher than the price at which it can be sold. This minimum size is a function of certain technical data which are valid irrespective of the location of the installation (material balance Sheet - thermic balance Sheet), but it depends also on certain set local conditions (cost of public utilities and manpower, of raw materials, distance to the country constructing the installations, distance to the country exporting the end-product) and also of certain optional conditions (method of financing, taxes on profits, period of amortization). The importance of these factors will be made more explicit by means of a complete study of an installation.

Another factor, which is characteristic of petrochemistry, the industrial complex, will be studied by means of a second example. This arises from the multiplicity of products deriving from the same chemical operation. In fact, because of the complexity of the raw material, it is not generally possible to obtain sufficient selectivity in the processing in order to

obtain the desired product, without also obtaining a large quantity of by-products which must be put to account. This obligation calls for new installations that increase investments and could cause certain difficulties in the general revenue of the operation.

These difficulties, which should not be disregarded, can be resolved if a detailed study plan is implemented which permits the choice of the best solution under the circumstances in question.

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Agenda Item: D.2.3

United States of America

THE ROLE OF SMALL AND MEDIUM INDUSTRY IN DEVELOPMENT

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THE ROLE OF SMALL AND MEDIUM INDUSTRY IN DEVELOPMENT

by
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1. Large factories are a characteristic feature of the modern industrial economy, but they are not the whole of it. Despite the well known "economies of scale," manufacturing is not always and everywhere more economical in large than in small establishments. This is true even in the highly industrialized countries. It is still more true in newly industrializing countries where markets are smaller, systems of transport, communication, and product distribution are less developed, and there is less experience with large-scale organization. A country will achieve the most productive industrial structure by developing a well chosen combination of large and small manufacturing units, the place of each determined on the basis of economic efficiency.

2. Often, in countries striving to industrialize, small-scale manufacturing has been regarded as an inevitably backward and lagging part of the economy, perhaps to be aided for social reasons and in a rather defensive or protective spirit, but not as a promising opportunity for development. In most industrialization programs, too little attention has been paid to the benefits to be gained by helping existing small industry to modernize and by stimulating the growth of new, modern small industry. A latent resource has thus been overlooked and neglected.

CHARACTERISTICS OF SMALL AND MEDIUM INDUSTRY

3. Small industry means manufacturing carried on in relatively small establishments. Before giving a quantitative interpretation to "relatively small," however, it will be useful to note some non-quantitative functional characteristics which distinguish small industry from large industry. These are the characteristics which justify separate discussion of the role of small industry in development and the adoption of special development programs for small industry. (Medium industry, of course, stands between small and large industry with respect to these characteristics.)

4. Most important is (1) the relative lack of specialization in management. The small manufacturing firm characteristically depends on "one-man management," generally by an owner-manager, perhaps with a few assistants. The very large firm, by contrast, can have a vice-president for production, a vice-president for sales, a vice-president for finance, and a vice-president for research. Other characteristics are (2) lack of access to capital through the organized securities market and handicaps in obtaining capital and credit through other channels, (3) no special bargaining strength in buying or selling in a major market, and (4) often, though

not always, a relatively close integration with the local community through local ownership and management and dependence on nearby markets and sources of supply.

5. These characteristics give the small manufacturing firm certain disadvantages and certain special needs for types of advice and aid that are not so much needed by large firms. They also confer some advantages, chief of which is flexibility. The close personal contact which "one-man" management makes possible between the manager and workers, customers, and suppliers can be, if the manager is a good one, a source of strength in many ways. This goes far to explain why, and in what kinds of manufacturing, modern, well-managed small industry can compete successfully with large industry--as will be seen below.

USE OF TERMS

6. One obstacle to clear thinking about the role of small and medium industry in economic development is the confusion over use of terms. A United Nations report on The Development of Manufacturing Industry in Egypt, Israel, and Turkey (1958) refers to manufacturing establishments employing ten or more persons as "medium-scale and large-scale," thus limiting the term "small-scale" to establishments with less than ten persons. A Working Group of the Economic Commission for Asia and the Far East some years ago suggested that small industry be defined for statistical purposes as establishments with no more than 20 employees when using motive power or 50 when not using power.

7. Governments which offer special assistance to smaller manufacturing firms use diverse administrative definitions. In India until 1960 the Government's small industry program was directed to establishments having no more than 50 employees with power or 100 without power and no more than Rs. 500,000 (about US$100,000) of fixed capital. Now there is no limitation on number of employees; only the capital limitation applies. In Japan, various laws for assisting "smaller enterprises" recognize an upper limit in manufacturing of 300 employees, sometimes with a capital limitation of 10 million yen (about $28,000). In the U.S.A., a manufacturing firm is officially a "small business" for purposes of government financial and other assistance if it has fewer than 250 employees, and large if it has more than 1,000, but within the 250-1,000 range it may be classified either small or large, depending on size standards set for different industries. Obviously, discussion of small and medium industry may proceed at cross purposes unless we take care to define what we mean.

8. The most serious confusion results from a tendency to identify smallness with certain other characteristics. Thus, "small industry" and "village industry" are sometimes lumped together, which is unfortunate because small-scale manufacturing goes on not only in villages--that is, in rural areas--but in urban areas as well. More important, smallness and outmoded techniques are often treated as inseparable. The Economic Survey of Europe, 1959, in its illuminating chapters on "Development Problems in Southern Europe and Ireland," refers several times to the "modern" as contrasted with the "small-scale" industrial sector. At present it is undoubtedly true that the great majority of small-scale manufacturers in the less industrialized countries have backward technology, inefficient management, and low productivity. But these are not inevitable characteristics of small industry. There are modern, efficient, small manufacturing enterprises in many countries, and in some of the highly industrialized countries the average labor productivity in small plants is not very far below that in large plants.

9. Any definition of "small" or "small and medium" industry in measurable

terms, as required for statistical studies and for administration of special kinds of aid, cannot avoid a certain arbitrariness. It is like defining "hot" water. And just as the concept of "hot" water depends on whether one is thinking of shaving or of running a steam turbine, so definitions of small and medium industry can reasonably be different in countries at different stages of development and for different purposes. However, it is important to be clear, and it would be advantageous to achieve a fairly consistent international use of terms.

10. There is no single satisfactory way of measuring the size of an industrial establishment. Besides number of employees, other possible measures are capital investment, output, amount of energy used, and relative position in the industry. All of these are relevant in any complete characterization. Number of employees is, however, the most widely available, the most convenient, the most readily comparable internationally, and on the whole probably the least objectionable for general purposes. At Stanford Research Institute, where for some years we have been engaged in basic research and field work on the role of small industry in development, we have decided for the purpose of statistical comparisons (recognizing the arbitrariness of all such decisions) to call manufacturing establishments with less than 100 workers "small industry," those with 100-249 workers (or thereabouts, where census data break differently) "medium," and establishments with 250 or more "large." Within the "small industry" group, we find it wise to separate out, where possible, establishments with less than 10 employees. We label them "very small." Those with 10 to 49 employees we label "the central group," and those from 50 to 99 "small-to-medium." However, one of our field teams which recently worked with the Banco Popular in Colombia on a joint study leading to special measures for small and medium industry development found that in Colombian conditions the most appropriate definitions, both for analytical and program purposes, were: Small factory, 10 or more persons engaged and gross assets below 500,000 pesos (about US$50,000); medium factory, less than 100 persons engaged and gross assets from 500,000 to 2 million pesos (about US$50,000 to US $200,000).

PROSPECTS FOR DIFFERENT TYPES OF SMALL INDUSTRY

11. It is essential to distinguish a number of types of small industry, for these different types have very different prospects as a country transforms itself from a traditional, pre-industrial into a modern, industrial economy.

12. One important distinction is that between traditional small industry and modern small industry--the latter defined as manufacturing units in which reasonably good application is made of the best science and technology currently available. It is <u>modern</u> small industry, or movement toward it, which holds promise for newly developing countries.

13. It is also important to distinguish between household industry, artisan industry, and small factories.

14. Household industry is manufacturing carried on in or near the home, mainly by family labor. It is sometimes called cottage industry, though more properly this term might be reserved for rural household industry. This is the oldest form of manufacturing, and it is still important in many countries that are striving to modernize. Undoubtedly it will continue to be important in these transitional economies for a long time. Well planned measures to improve and regulate household industry will be needed. But the long-term trend in developing countries will be, and on economic and social grounds ought to be, for household

industry to disappear, save for special functions. Among such special functions are providing work for the handicapped and for dwellers in isolated places, part-time supplementation of seasonal incomes of farmers in some situations, and production of handicrafts of an artistic and quasi-hobby sort. For ordinary production of manufactured goods, household industry is inefficient and is subject to social abuses that are practically impossible to control, such as extremely low rates of pay, long hours, and child labor. Development planners in newly industrializing countries will do well to regard their household industries as a temporary form, to be supplanted over the long term by small and medium factories, artisan workshops located outside the home, and large factories.

15. Artisan industry is manufacture carried on in workshops by craftsmen working singly or with a few hired helpers or apprentices and without extensive division of labor. The craftsman (artisan) is central, and articles are produced for the most part one at a time with individual variations, often to the requirements of a particular customer. The potters, weavers, blacksmiths, shoemakers, bakers, and other ancient crafts are examples of "old line" artisan industry. As a country moves from traditional towards modern economy, some of the old crafts will decline, as a result of competition with factory goods and changes in tastes. Still more crafts will undergo readjustments by which they will become "service trades" and in this form will supplement rather than compete with factory goods. "New line" artisan activities will arise, such as automobile repairing, installation and repair of electrical equipment, and photographic work. Artistic handicrafts, and craftsmanship in the design, decoration, and individualization of factory goods will find increasing markets. Readjustments such as these, especially the growth of service trades, have belied predictions which were common a half century ago in the then industrializing countries of Europe that factory competition would lead to the disappearance of the artisan. The highly industrialized economies of today seem, on the contrary, to be using increasing numbers of artisans whose functions have undergone a transformation from the making of manufactured goods to their installation, servicing, and repair. Often these functions are combined with retail trade.

16. The long-term problem of the newly industrializing countries with respect to artisans is to help them readjust in a changing environment which presents both new opportunities and new competition. The transitional adjustments will not be easy. But the basic strategy must be to help the artisans in one of two ways: (1) Some can be helped to adapt their skills to the rising modern demands, forsaking the declining traditional demands. This means village blacksmiths learning to install and repair irrigation pumps and diesel engines, skilled weavers concentrating on designs and qualities not readily reproducible by machine, shoemakers turning to shoe repairing. (2) Others must be guided into entirely new occupations, preferably occupations for which the demand is rising as development takes place.

17. The small factory is distinguished from artisan industry by its greater division of labor and the consequent need for planning and coordination. The manager rather than the craftsman is the central figure. In larger factories management itself has to be subdivided, and specialists handle such tasks as production management, product design, sales management, personnel management, and financial management. The small factory has much less division of labor in management, and the medium factory an intermediate amount. As already noted, this is a source both of weakness and of strength in the smaller-scale units. If there is right choice of product lines and skilled management, small units can emphasize their areas of strength and avoid those in which they are too greatly handicapped.

18. The outlook for modern, progressively managed small and medium factories in newly industrializing countries is therefore favorable. Well-conceived programs designed to foster this sector can be important tools of development. However, the utility of such programs will depend on the kinds of small manufacturing industry that are encouraged and how they are encouraged. An economically sound program for small and medium industry development is one that fosters selectivity in the choice of product lines and efficiency in production and business operations.

19. The benefits which an industrializing economy can gain by intelligent promotion of this sector may be summarized as follows:

(a) Small and medium firms serve as a nursery for entrepreneurial talent, for growth in some cases into large industry.

(b) Alert owner-managers in intimate contact with market needs and possessing practical technical competence are important sources of product innovation and adaptation.

(c) The limited size of the home market in many newly industrializing countries makes production on the scale that is usual in the major industrialized countries unfeasible. Smaller plants may be able to produce quantities required by the smaller market at reasonable cost, if provided information on current product opportunities and if given technical and managerial guidance and stimulus to efficient performance.

(d) Efficient and forward-looking firms, even though of modest size, can contribute to development of export trade, especially if market exploration is undertaken cooperatively and with government help.

(e) Vigorous small and medium factories help to check monopoly, improving prices and services to consumers.

(f) Small and medium manufacturers are usually local entrepreneurs, and the healthy growth of their firms helps to balance the importation of foreign capital and the growth of foreign-owned enterprises.

(g) Small and medium enterprises add to employment opportunities.

(h) Such enterprises tap sources of capital (especially from family savings and, if the enterprise is successful, from plowed-back profits) which would not otherwise contribute to the country's capital formation.

(i) Small and medium factories can be important in local and regional development and in promoting a more decentralized pattern of industrial growth.

(j) Vigorous small and medium industry helps to create an active tradition of independent initiative by alert individuals and a strong middle class, which in turn is important as underpinning for political democracy.

THE ECONOMIC BASIS FOR MODERN SMALL FACTORIES

20. It is sometimes asked, "Will not the large manufacturing firms drive out the smaller ones? Can the small enterprise, lacking a staff of specialists and with limited access to capital, compete against large, highly organized, highly capitalized firms?" The answer is that while many small factories can and do compete successfully, others do not compete directly with large factories but rather serve as a complement to them. That many small manufacturing establishments do in fact manage to compete or to co-exist, even in the most highly industrialized environment, is shown in Table 1.

TABLE 1

ROLE OF MANUFACTURING ESTABLISHMENTS HAVING FEWER THAN 100 EMPLOYEES

Country	Year	Percent of all Manufacturing Establishments	Percent of all Manufacturing Employees [1]	Percent of all Manufacturing Output [2]
U.S.A.	1958	91	27	23
West Germany	1953	89	27	23
United Kingdom	1954	95	33	n.a.
Puerto Rico	1954	91	41	38
Australia	1955	97	50	n.a.
Japan	1952	99	59	37

n.a. Not available.

1. United Kingdom, percent of workers.
2. U.S.A. and Puerto Rico, value added by manufacture; West Germany, turnover excluding goods purchased and resold without processing; Japan, value of shipments.

Sources: U.S.A.--Bureau of the Census, Census of Manufactures, 1958.
West Germany--Statistisches Bundesamt, Statistisches Jahrbuch für die Bundesrepublik Deutschland, 1955.
United Kingdom--Annual Report of the Chief Inspector of Factories for the year 1954.
Puerto Rico--Puerto Rico Planning Board, Statistical Yearbook, Puerto Rico, 1957.
Australia--Australia Commonwealth Bureau of Census and Statistics, Official Year Book of the Commonwealth of Australia, 1957.
Japan--Office of the Prime Minister, Bureau of Statistics, Japan Statistical Yearbook, 1954.

21. In the United States in 1958, as the table shows, more than 90 percent of all manufacturing establishments had fewer than 100 employees. These establishments employed 27 percent of all manufacturing employees and produced 23 percent of the total value added by manufacture. Incidentally, the fact that these smaller factories accounted for not very much less in proportion of value added

than their proportion of employment shows that their average labor productivity is not very greatly below that of the larger factories. The relative importance of small factories is as great or greater in West Germany and the United Kingdom, and considerably greater in Puerto Rico, Australia, and Japan.

22. Here are some of the factors which enable small and medium factories to compete or to co-exist successfully with large industry:

(a) Economies of scale are less important in some lines of production than in others. In blast furnaces and cement kilns there are great engineering advantages and cost advantages in using big pieces of equipment to handle large amounts of materials, so that these are not undertakings suitable for small units. But in the manufacture of garments or certain kinds of machine tools the advantages of scale are much less significant, and a moderate sized plant may be just as efficient as, or even more efficient than, a large one.

(b) Small units have an advantage where shipping costs are high or the product is perishable. Thus, bricks and tiles and fresh baked goods can be produced more economically by relatively small, local establishments than by great central factories.

(c) Small manufacturing establishments have an advantage in meeting highly specialized or individualized demands or in catering to a small volume market or one requiring frequent quick readjustments because of style changes or for other reasons. They compete very well in certain kinds of precision instruments, some types of specialized machinery, some types of surgical equipment, women's wear, and so on. Here the flexibility of the small firm stands it in good stead. Large enterprises are handicapped by their bureaucratic procedures and their relatively large overhead expenses. It does not pay for them to produce short "runs" of a non-standard item, but the small factory can often do so at a profit.

(d) Where labor and social laws are applied more stringently to large than to small plants, as is often the case in newly industrializing countries, this may be a factor (whether or not a desirable one) in the competitive ability of small plants.

(e) The small factory can "fill the cracks" between the large-volume, standardized outputs of large factories. Many small manufacturers produce specialized sizes or styles or slightly different products for which the demand is not great enough to justify large-scale production but still large enough to provide an attractive market for them. For example, a very successful small cycle manufacturer near Madras, India, produces junior size bicycles, also tricycles and tricycle-mounted delivery carts, thus supplementing rather than competing with a major bicycle factory in his immediate vicinity.

(f) The small factory can produce components and supplies for large factories. Much of Japanese small industry works on contract for large industry. One of the reasons for the efficiency of industry in the United States is that large plants characteristically buy many specialized parts from hundreds or even thousands of other plants, both large and small. A small enterprise supplying a

specialized item to several large firms may have greater economies of scale on that item than any of the large firms could obtain. Also, small industry often performs job shop operations for large industry.

(g) The small factory often serves to initiate new products, and sometimes grows large with growth of the market for the product. Henry Ford and other pioneer automobile manufacturers started on a very small scale. The electronics industry today is bursting with small firms, as well as large ones, hopefully exploiting new ideas. In countries where industrial diversification is at an early stage, small-scale manufacturers can discover opportunities to introduce products that are new to the country though not necessarily new in the world.

POLICY IMPLICATIONS

23. The policy implications of the preceding analysis may now be summed up.

24. First, development leaders in countries striving to accelerate the rate of industrial advancement will do well to give attention to the constructive possibilities in modernization and growth of small and medium industry.

25. Second, as a country moves through the transitional stage from a traditional toward a modern economy, the outlook is for household industry to be replaced, for artisan industry to be transformed, and for the small but modern factory to be developed and to increase in importance.

26. Third, these shifts can be made much more productive if they are properly guided. Some product lines and some situations offer opportunities for efficient small-scale manufacturing and others do not. Conditions vary from country to country, from region to region in the same country, and from time to time as a country develops. Therefore, continuous research to provide up to date analysis of changing markets, production methods, costs, and other economic and technical factors is advisable in a program of small and medium industry development. It will also be necessary to have some type of communication system, such as an industrial advisory service or industrial extension service, to carry to existing or potential entrepreneurs the information on which they can base sound investment decisions.

27. Fourth, much depends on improving the efficiency of management in small-scale enterprises and on introducing improved production technology. This again suggests the need for some type of industrial advisory service. Among its functions would be to encourage a progressive outlook among small entrepreneurs and to keep feeding them improved ideas on the economic, technological, and management problems of their enterprises. These ideas should be based on the best modern techniques of production and management, suitably adapted to smaller-scale operations.

28. This last point has a direct bearing on the application of science and technology for the benefit of less developed areas. Significant help could be given in the advancement of the newly developing economies by devoting more scientific and technological effort to the serch for methods of increasing the efficiency of comparatively small-scale production units.

DESIGNING A DEVELOPMENT PROGRAM FOR SMALL AND MEDIUM INDUSTRY

29. What types of practical development aids should be considered in designing a positive program to improve the efficiency and promote the growth of small and medium industry? The following checklist is offered:

(a) Industrial Advisory or Counseling Services. Some of the principles and techniques that have made agricultural extension services valuable instruments of agricultural improvement are now being applied for small industry development in a number of countries. . A small industry advisory service or industrial extension service should give counsel on two kinds of problems: (1) economic and business management problems, including the choice of promising lines of manufacture, marketing, costing, financing, and personnel management and (2) technical production problems, such as plant layout and better use of machines and materials. An industry advisory service needs a trained staff, closely linked with and backed by industrial training services, research services, financing services, and all the other developmental aids.

(b) Industrial Training Services. For effective development of modern small industry, training programs are needed for: (1) managers, (2) supervisors and foremen, (3) technicians, and (4) skilled workers.

(c) Industrial Research Services. Applied research is constantly needed in order to adapt the best available science and technology to the special needs of existing or potential industries and, through the counseling service, to make the results available to small industrialists. Two kinds of research are important: (1) research on problems of economics and business management affecting the prospects and operations of small industry, and (2) research on technical production problems.

(d) Measures to Improve Small Industry Financing. Small industry generally needs financial counseling. Also, special institutional devices are necessary to cope with the problems and risks peculiar to the financing of this sector of the economy.

(e) Industrial Estates. An industrial estate is a tract of land on which industrial utilities are installed (roads, water, electricity, etc.) and on which standard-type factory buildings are erected for lease or sale to manufacturing firms or on which firms may build their own buildings in conformity with designs approved by the estate. This greatly aids small and medium enterprises, for they are able to have suitable premises and utilities without the burdensome tasks of acquiring land, obtaining all necessary permits, and obtaining access roads and electric power connections. The offer of factory premises on a rental or installment-purchase basis is also a good way of making financial help available to promising small industrial enterprises. Industrial estates are likewise an important tool for city planning and the control of urban growth.

(f) Marketing Aids. The small industrialist, especially if he enters

manufacturing from the craftsman or engineering side, oftentimes fails to do an adequate job of marketing. He can be helped in a number of ways. One of the most important aids is marketing information, based on economic investigations and market surveys which small firms are not in a position to undertake themselves. Trade fairs, expositions, trade directories, and special assistance in making export contacts are helpful devices. Larger firms can be encouraged to contract with smaller firms for component parts and supplies. In some countries a deliberate effort is made to channel suitable portions of government purchases to smaller manufacturers.

(g) Aid in Procurement of Materials and Equipment. The small manufacturer suffers handicaps in purchasing as well as marketing. Therefore, development programs sometimes promote bulk purchasing arrangements for groups of small enterprises, through purchasing cooperatives or governmental agencies. Where important supplies, domestic or imported, are subject to allocation and control it is highly advisable to establish special, simplified procedures adapted to the needs of small manufacturers.

(h) Fostering Interfirm Assistance and Industrial Self-Help. In some countries, such as the northern countries of Europe, trade associations or associations of small industrialists have proved themselves capable of carrying on advisory services, training services, research services, and financial services for their members--often with the aid of government subsidies. Large manufacturing firms can also be an important source of technical assistance for the many small firms among their customers and suppliers. The exchange of ideas and information at trade meetings and conventions, through trade periodicals, and in other ways can be an important factor in industrial progress. Small industry development may well include efforts to stimulate constructive activities of these various types.

30. A development program for small and medium industry need not, of course, include every type of measure on the foregoing checklist. It should, however, be reasonably comprehensive. Usually it does little good merely to set up an institution for making capital and credit more readily available to small industry without, for example, doing anything to improve techniques of production and management. An action program, to be effective, must push outward simultaneously on a considerable number of limiting factors. Which factors are most strategic in the circumstances of a particular country should be determined by a preliminary survey. Usually the limiting factors so revealed will be multiple, and the action program will need to be a broad, integrated one, so that each kind of assistance reinforces the other kinds and is reinforced by them.

31. Each country requires a set of measures tailormade in general approach and in detail to its own situation. Valuable ideas can, however, be had by studying the experience of other countries. Among the less industrialized countries, India has by all odds the largest, most comprehensive, and the best planned program for small industry development. At a further stage of industrialization, Japan has evolved a wide array of measures which well merit study. The United States has an active "Small Business Administration" which aids small and medium manufacturers and other types of small business, supplementing many aids provided through other public institutions and through the private business system. The Scandinavian countries, the Netherlands, Germany, the United Kingdom, France, Italy, and other European countries, also some of the Provinces of Canada, have

adopted a variety of measures with different emphases, sometimes focussing on the financial needs of small manufacturing units, sometimes on technological and managerial training and productivity improvement, sometimes on product design and marketing. In Puerto Rico there is an active industrial development program in which a large proportion of the enterprises that have been started are small units, and a number of other Latin American countries--Mexico, Brazil, Colombia, and others--have special banking institutions designed to stimulate small industry, also industrial development centers, industrial research institutes, productivity centers, and the like. Indonesia, Burma, Pakistan, and the Philippines are using various techniques of small industry promotion, and the Federation of Malaya is strengthening its Rural and Industrial Development Authority. In Africa, Nigeria has been experimenting with industrial estates and other measures and is considering a more comprehensive small industry program.

32. It should be stressed, however, that no system worked out in one country can be recommended in its entirety for another. Rather, the development officials of each country must analyze their particular country's small industry problems and opportunities, then borrow some ideas and invent others, in order to act creatively and practically in their specific situation.

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FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.2.3

United States of America

THE ROLE OF SMALL AND MEDIUM INDUSTRY IN DEVELOPMENT

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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

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THE ROLE OF SMALL AND MEDIUM INDUSTRY IN DEVELOPMENT

by

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Menlo Park, California, USA

1. Despite "economies of scale," manufacturing is not always more economical in large than in small establishments, and a country will achieve the most productive industrial structure by developing a well chosen combination of large and small manufacturing units. Development leaders in countries striving to accelerate the rate of industrial advancement will do well to give attention to the constructive possibilities in modernization and growth of small and medium industry. It is important, however, to stress selectivity in the choice of product lines and efficiency in production and business operations.

2. As a country moves through the transitional stages from a traditional toward a modern economy, the outlook is for household industry to be replaced (except for special functions) and for artisan industry to be transformed into modern service trades. The small but modern factory will rise in importance. Such factories, if well managed, have distinctly favorable prospects in the newly industrializing countries.

3. Some product lines and some situations offer opportunities for efficient small-scale manufacturing and others do not. Therefore, continuous research to provide up to date analysis of changing markets, production methods, costs, and other economic and technical factors is advisable in a program of small and medium industry development. It is also necessary to have some type of communication system, such as an industrial advisory service or industrial extension service, to carry to existing or potential entrepreneurs the information on which they can base sound investment decisions. Such a service should also encourage a progressive outlook among small entrepreneurs and keep feeding them improved ideas on the economic, technological, and management problems of their enterprises. These ideas should be based on the best modern techniques of production and management, suitably adapted to smaller-scale operations. Significant help could be given in the advancement of the newly developing economies by devoting more scientific and technological effort to the search for methods of increasing the efficiency of comparatively <u>small-scale</u> production units.

4. Among the practical measures which should be considered in designing a positive program to improve the efficiency and promote the growth of small and medium industry are: (1) industrial advisory or counseling services, (2) industrial training services, (3) industrial research services, (4) measures to improve small industry financing, (5) industrial estates, (6) marketing aids, (7) aid in procurement of materials and equipment, and (6) fostering interfirm assistance and industrial self-help.

5. A development program for small and medium industry should be reasonably comprehensive. Usually it does little good merely to set up an institution for making capital and credit more readily available without, for example, doing anything to improve techniques of production and management. Which factors are most strategic in the circumstances of a particular country should be determined in a preliminary survey. Valuable ideas can be had by studying the experience of other countries--for example, India, which has the best planned and most comprehensive small industry program among the less industrialized countries. However, it should be stressed that no system worked out in one country can be recommended in its entirety for another. Each country requires a set of measures tailormade in general approach and in detail to its own situation.

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Agenda Item : D.3

Italy

POSSIBILITY OF DEVELOPMENT OF SEMICONDUCTOR INDUSTRY IN UNDERDEVELOPED COUNTRIES WITH REGARD TO THEIR ECONOMIC MEANS AND MODERN TECHNOLOGY

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POSSIBILITY OF DEVELOPMENT OF SEMICONDUCTOR INDUSTRY IN UNDER-DEVELOPED COUNTRIES WITH REGARD TO THEIR ECONOMIC MEANS AND MODERN TECHNOLOGY

by

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It's commonly believed that the semiconductor industry is synonym of a very advanced technology, which may be put profitably to work only in the more industrialised countries.

As a matter of fact, since 1948, the most important achievements in this field came from USA, although a lot of subsidiary techniques were developed in Europe, including specially the basic metallurgical principles on which the semiconductor industry rests.

However, the greatest majority of the actual devices have been developed in the States, with practically no exception, the most important ones being perhaps the post alloy diffused transistor, PADT, of Philips, Holand, and the tunnel diode due to Eisaki, Japan.

Since 1952, anyhow, demand for semiconductor devices has grown to such an extent that a mass production of highly sophisticated devices was requested. The "laboratory production" of the early fifties has been replaced by more repetitive technologies.

Only very special types are still produced under laboratory conditions on a small scale.

Advanced technologies are not, however, the single reason for the widely held opinion that the semiconductor industry does not fit the present needs of the less developed countries.

Lack of demand, the high import requirements and the unbalancing effect of a semiconductor industry not integrated within a well established electronic industry, provide further arguments for such a belief.

It is our opinion that establishing a semiconductor industry might be a fairly good investment of the scarce resources of at least some of the new emerging countries, and that therefore, planners and economists should not overlook it as they seem to do (1).

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(1) An example is provided by the Third Five Year Plan of India where production of semiconductor is considered only as a "laboratory production" to be made by the Electronic Division of the Atomic Energy Commission.

The first factor on which we like to call the attention is the recent development of some basic technologies, substancially founded upon a more solid know-how (and in some cases upon what we could call "tricks") of processes that permit to avoid many of the big difficulties encountered in early years. The yield of production lines in terms of marketable units has increased to 70-90% as compared to 20-40 per cent around 1954.

Yet, the great number of highly repetitive elementary operations, necessary in the building-up of semiconductor devices, are well suited for a production through unexperienced manpower, who may acquire, in a very short time, all the ability and skill necessary.

In Italy young girls who never worked in a factory before, proved to be after a few months excellent labourers for the production lines of transistors. In the United States many semiconductor plants are located in rural areas of the South and make a large use of coloured unskilled workers.

We do not see why this should not be possible in some of the less developed countries.

Apart from unskilled manpower, the semiconductor industry requires a certain number of very well prepared technicians. Their number being proportional to the degree of sophistication of the devices produced and to the amount of original research that is carried out. If a plant for the production of 500 thousand high power silicum rectifer per annum might require 50 workers and 10 to 12 qualified scientists and engineers, a plant of the same size for entertainement transistor, might produce 4-5 million marketable units per years with the same amount of unskilled labor and 6 or 7 qualified techniciens.

We do agree that the new emerging countries might be lacking a large amount of highly qualified technicians, but not the few that are required for low quality production. India, for instance, has quite a number of scientists working on atomic projects and so do other less developed nations.

As to original research, which is a must for industries working in a very competitive environment a for a very exacting market, it is not an absolute need for an industry working mostly for the entertainement market. Most of the semiconductor companies established in Europe have links with North-America companies, so do also many Japanese companies; the same pattern might be followed for establishing a semiconductor company in backward areas.

Cheap manpower has in the semiconductor industry a very important role because of the quick rate of obsolescence that the continous improvements in the state of the art imposes upon fixed machinery.

Automatic operations require very sophisticated machinery and apparatus, the depreciation cost of which may be a substancial part of the cost of each unit.

For example, the cost of the equipment for an automatic line (PHILCO), requiring five skilled persons (1), for the production ofa about 1000 transistor per hour, is evaluated at 400.000$: that means, considering a yield of 80% and a technological obsolescence of two years, 0.10 $ per unit of depreciation cost, which might not be born if the selling price of transistors is in the range of fifty cents.

(1) It has to be emphasized that in case of any failure in the automatic equipment, quite a number of highly specialized technicians are requested.

Another main characteristic of the semiconductor industry is the convenience of a low fixed investment also in the advanced countries because highly automatic lines of production need a large amount of capital and the time necessary for the complete design may render obsolete the device.

Moreover, the automatic production requires more elaborated parts to be fed into the line, which is another cause of increased costs.

We have shortly discussed the problem from a general view point; to give more strength to our argument we shall now try to give some estimates of hypothetical comparative costs.

Of course we are fully aware of the intrinsic weakness of the so called "engineering estimates" such as those we are using. Nevertheless it seems to us that they are sufficient to point out the right direction.

Let us consider two representative semiconductor devices, characterised by a well known technology, comparing the cost of the units in two different countries:

1) Italy (IT) where a manpower cost of 1 $ per hour has been considered, and where some automatic operations are still convenient

2) Hypothetical Underdeveloped Country (HUC), where a manpower cost of 35 c per hour has been considered.

The devices taken into consideration are:

a) low-power (200mW) general purpose Germanium alloy transistor (GeLP)

b) power (3-20W) Germanium alloy transistor (GeLP)

a) GeLP - 2 millions good units per year
(considering a yield of 80%)

It - Line investment, from wafer sorting and cutting to automatic final testing, including headers production.....140.000$

HUC - Line investment, same consideration, with manual final testing 70.000$

Cost of a marketable unit (cents)

	IT		HUC	
- Materials and parts	14,00	62,3%	11,00	63,1%
- Chemical, gases Denion. Water	1,00	4,4%	2,00	11,5%
- Manpower (30 workers + 2 foremen)	3,70	16,4%		
- Manpower (60 worker + 5 foremen)			2,50	14,4%
- Depreciation	3,50	15,5%	1,75	10,0%
- Interest on invest	0,28	1,2%	0,21	1,2%
TOTAL	22.48	100(a)	17.46	100(a)

(a) approximately

The cost per unit is calculated on the basis of the prices of the parts and apparatus as they are available in Italy. The rate of interest taken into account was 8% in Italy and 12% in the hypothetical underdeveloped country to consider the different availability of capital.

Depreciation was calculated - according to the prevailing standards of the industry - upon the basis of a two years obsolescence. It is however clear that in an underdeveloped country where technological progress is not so quick, depreciation might be spread over a much longer period. The more so if production is meant for the entertainement market.

We do not pretend to give here the absolute values, which may be, perhaps slightly lower, but to furnish a comparison between the two possibilities; the cost HUC is about 20% lower.

The difference between the two investments is mainly due to: 1) The cost of automatic test equipment which can be evaluated between 30,000 and 40,000 $; 2) the cost of automatic machinery which is necessary with a relatively low number of workers. The last argument causes also a decrease for HUC, in the cost of direct materials and parts, which are less elaborated because of more manual operation.

We took into account a greater difficulty for HUC to get proper chemicals and, especially, good quality gases. The figure of 2 c per unit, in that case, depends largely from the conditions of the corresponding industry in each country.

It's possible, anyhow, to import large stocks of liquid gases of high purity.

So, the figure quoted should not be substancially incorrect.

b) GeHP - 500,000 good units per year
(considering a yield of 70%)

IT - Line investment, from wafer sorting and cutting to final testing (we do not consider here the automatic test equipment because yet considered from GeLP), including headers manufacturing ..... 50,000 $

HUC - Line investment, same conditions as above, plus 6,000 $ of final test equipment, including headers manufacturing ..... 56,000 $

Cost of a good unit (cents)

	IT		HUC	
- Material and parts	22.4	49.0%	22.4	53.7%
- Chemicals, gases Deion. Water	3.0	6.5	6.0	14.4
- Manpower (30 Workers + 2 foremen)	15.0	32.7		
- Manpower (30 Workers + 3 foremen)			6.4	15.3
- Depreciation	5.0	10.9	6.0	14.4
- Interest	0.4	0.9	0.9	2.2
TOTAL	45.8	100%	41.7	100%

This represents a completely different situation, the difference in two cases being about 10%, in favour of HUC. This is only due to the manpower cost; the other costs are equal or higher, apart from the already mentioned considerations on depreciation.

The power transistor is the typical case for which, as far as we know, automatic productions are reduced to a minimum: the manpower is the greatest part of manufacturing cost.

As we mentioned before, we didn't take into consideration tha cost of an automatic final test equipment because it was considered previously for GeLP.

We consider that such an apparatus could be used for both GeLP and GeHP at the same time.

We came practically at the same results as for GePH, with another typical device, a low cost medium current silicon rectifier (10-50 A / 50-300 PIV), which space limitations prevent us to expose here.

In fact the two cases presented here, GeLP and GeHP, are, in our opinion the two extreme possibilities between which we may classify, from the economical viewpoint, the greatest majority of the semiconductor devices actually produced, excluding the most advanced ones which are due, as we said precedently, to a "laboratory production" For those devices the cost evaluation is particularly hard, and we shall not even try to provide our.

We didn't take into consideration, here, the investment for the general services because that is a function of the size of plant and of climatic conditions which cannot generalised. Moreover, the possible higher cost of installation in HUC may be compensated by the lower cost of less automatic equipment and of maintenance.

Furthermore it's not unconceivable, in HUC, a manpower yield superior to that of other countries (a figure of 60-70% is quite common in USA), because of this possibility of a larger selection, thus contributing to lower the figures here quoted for that, in the case HUC. On the contrary, if instead of Italy we had choosen a more high salary representative of the industrialized countries, our estimates might have given even more favourable results for the underdeveloped country

Engineering estimates show that achieving lower absolute costs of not too sophisticated semiconductor devices in an underdeveloped country than in a fairly industrialized one, is not absolutely out of the realm of possibilities. If this were true the establishment of a semiconductor industry might be advocated on the ground of its foreign exchange earning capabilities. We do know, however, that due to lower labour costs in underdeveloped countries estimates would provide similar results for many other industries.

Although one could also consider the case for an industry promoted by foreign capital and technicians for the sake of enjoing lower costs in order to export to industrialized countries, it is safer not to take into account such a possibility. It is our contention that a market for semiconductors exists also in the emerging countries.

Even in these countries there is in fact a quite considerable demand of lasting consumption goods so as transistor radioreceivers, which could be produced from domestic electronic industries. It could really be dangerous discriminating between the different types of demand, making use of choise principles which are not so easy to define. Moreover it is necessary to remember that the wide diffusion of low-costing radio-receivers may be an indispensable previous statement for a mass teaching program using radio and television which are with no doubt very effective means.

India, for instance, envisages to increase its production of radio-receivers from 254 thousand in 1960-61 to 800 thousand in 1965-66 (1). Unfortunately we do not gave any breakdown as to traditional sets and trasistorised sets. Nevertheless the market of radio-receivers is large enough to support a domestic production of semiconductors. Brasil in 1957 imported 16.27 milion U.S. dollars worth of wireless apparatus of all kinds,

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(1) See Government of India Commission Third Five Year Olan. p. 504.

reduced to 9 71 in 1960. We do not know how much of this amount is formed by radio-receivers. Yet the exisistance of a domestic semiconductor industry might help the stablishment of a domestic production of radio-receivers.

Here comes the objections that the import requirements of the semiconductor are very high and that the establishment of such an industry is not in accordance with balanced growth.

As to the former consideration we must recognize that there is some truth in it Both initial equipment and a large part of materials have not be imported. Nevertheless since the added value in the semiconductor industry is usually high, this factor assumes a relatively minor importance; in any case this problem has to be studied in each country according its balance of payment situation.

Concerning the semiconductor industry and balanced growth, apart from any frontal attack upon the whole concept of balanced growth (1), it might be easy to reserve the case and show that unless there is a domestic semiconductor industry it is pretty difficult to start an electronic industry.

It is necessary about this matter to remember that the increase of electronic industries must be accompanied by a well proportioned program for teaching and preparing good technical staffs at all levels. Electronic industries need in fact a number of skilled technicians who must be chosen between those who have good turn for the requested education type, and must be therefore trained with care. The preparing of a convenient number of technicians is hence necessary not only to the development of the electronic industry but also of all industries and services, because these activities use always more diffusely electronic means. This diffusion is in her turn a favourable element for the development of electronic industry's market.

It is our deep believe that nothing is more important in the use of modern electronic technologies than experience and that such an experience requires not to jump any step. The production of semiconductors is the first step to be made to enter the electronic industry. Since the electronic industry is acquiring in the industrialised countries a growing importance and might soon play a strategic role in the growth of an economy, there is no substancial reason why the new emerging countries should once more miss this challenging opportunity.

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(1) See for this Albert O. Hirshman "The Strategy of Economic Development (New Haven 1958)

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SUMMARY

Agenda Item: D.3

Italy

POSSIBILITY OF DEVELOPMENT OF SEMICONDUCTOR INDUSTRY IN UNDERDEVELOPED COUNTRIES WITH REGARD TO THEIR ECONOMIC MEANS AND MODERN TECHNOLOGY

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POSSIBILITY OF DEVELOPMENT OF SEMICONDUCTOR INDUSTRY IN UNDERDEVELOPED COUNTRIES WITH REGARD TO THEIR ECONOMIC MEANS AND MODERN TECHNOLOGY

b y

A. Alberigi Quaranta - G.P. Bolognesi - F.A. Grassini

It's commonly believed that the semiconductor industry is synonym of a very advanced technology, which may be put profitably to work only in the more industrialized countries. Advanced technologies are not however, the single reason for the widely held opinion that the semiconductor industry does not fit the present needs of the less developed countries. Lack of demand, the high import requirements and the unbalancing effect of a semiconductor industry not integrated within a well established electronic industry, provide further arguments for such a belief. It's our opinion that establishing a semiconductor industry might be a fairly good investment of the scarce resources of at least some of the new emerging countries, and that therefore planners and economists should not overlook it as they seem to do. The first factor on which we like to call the attention is the recent development of some basic technologies, substantially founded upon a more solid know-how (and in s me cases upon what we would call "tricks") of processes that permit to avoid many of the big difficulties encountered in early years. The yield of production lines in terms of marketable units has increased to 70-90% as compared to 20-40% around 1954. Yet, the great number of highly repetitive elementary operations, necessary in the building-up of semiconductor devices, are well suited for a production through unexperienced manpower, who may acquire, in a very short time, all the ability and skill necessary. Apart from unskilled manpower, the semiconductor industry requires a certain number of very well prepared technicians. Their number being proportional to the degree of sophistication of the devices produced and to the amount of original research that is carried out. If a plant for the production of 500 thousand high power silicum rectifier per annum might require 50 workers and 10 to 12 qualified scientists and engineers, a plant of the same size for entertainment transistor, might produce 4-5 million marketable units per years with the same amount of unskilled labour and 6 or 7 qualified technicians. We do agree that the new emerging countries might be lacking a large amount of highly qualified technicians, but not the few that are required for low quality production. Cheap manpower has in the semiconductor industry a very important role because of the quick rate of obsolescence that the continuous improvements in the state of the art imposes upon fixed machinery. Another main characteristic of the semiconductor industryeis the convenience of a low fixed investment also in the advanced countries because highly automatic lines of production need a large amount of capital and the time necessary for the complete design may render obsolete device. We have shortly discussed the problem from a general viewpoint; to give more strength to our argument we shall now try to give some estimates of hypothetical comparative costs. Let us consider two representative semiconductor devices, characterized by a well known technology comparing the cost of the units in two different countries:

1) Italy (IT) where manpower cost of $ per hour has been considered, and where some automatic operations are still convenient; 2) hypothetical underdeveloped country (HUC) where a manpower cost of 35 $ per hour has been considered. The devices taken into consideration is: a) low-power (200 mW) general purpose germanium alloy transistor (GeLP), 2 millions good units per year (considering a yield of 80%). It - Line investment from wafer sorting and cutting to automatic final testing, including headers production .... 140.000 $; HUC - Line investment, same considerations, with manual final testing ..... 70.000$

Cost of a marketable unit (cents)

	IT		HUC	
Materials and parts	14,00	62,3%	11,00	63,1%
Chemical gases, deion, water	1,00	4,4%	2,00	11,5%
Manpower (30 workers+2 foremen)	3,70	16,4%		
Manpower (60 workers+5 foremen)			2,50	14,4%
Depreciation:	3,50	15,5%	1,75	10,0%
Interest of investsments	0,28	1,2%	0,21	1,2%
a) approximately TOTAL:	22.48	100 a)	17.46	100 a)

The cost per unit is calculated on the basis of the prices of the parts and apparatus as they are available in Italy. The rate of interest taken into account was 8% in Italy and 12% in the hipothetical underdeveloped country to consider the different availability of capital. Depreciation was calculated according to the prevailing standards of the industry upon the basis of a two years obsolescence. It is however clear that in an underdeveloped country where technological progress is not so quick, depreciation might be spread over a much longer period. The more so if production is meant for the entertainment market. We do not pretend to give here the absolute values, which may be perhaps slightly lower, but to furnish a comparison between the two possibilities; the cost HUC is about 20% lower. The difference between the two investments is mainly due to: 1) the cost of automatic test equipment which can be evaluated between 30,000 and 40,000 $; 2) the cost of automatic machinery which is necessary with a relatively low number of workers. The last argument causes also a decrease for HUC, in the cost of direct materials and parts, which are less elaborated because of more manual operation. We took into account a greater difficulty for HUC to get proper chemicals, and especially good quality gases. The figure of 2 $ per unit, in that case, depends largely from the conditions of the corresponding industry in each country.

b) GeHP - 500,000 good units per year (considering a yield of 70% - power (3-20W) general purpose Germanium transistor (GeHP))

IT - Line investment from wafer sorting and cutting to final testing (we do not consider here the automatic test equipment because yet considered from GeLP), including headers manufacturing --- 50,000 $ HUC $ line investment, same conditions as above, plus 6,000 $ of final test equipment, including headers manufacturing ---- 56,000 $

Cost of a good unit (cents)

	IT		HUC	
Material and parts	22.4	49.0%	22.4	53.7%
Chemical gases deic, water	3.0	6.5	6.0	14.4
Manpower (30 workers + 2 foremen)	15.0	32.7		
Manpower (30 workers + 3 foremen)			6.4	15.3
Depreciation:	5.0	10.9	6.0	14.4
Interest:	0.4	0.9	0.9	2.2
TOTAL:	45.8	100%	41.7	100%

This represents a completely different situation, the difference in two cases being about 10% in favour of HUC. This is only due to the manpower cost; the other costs are equal or higher, apart from the already mentioned considerations on depreciation. The power transistor is the typical case for which, as far as we know, automatic productions are reduced to a minimum; the manpower is the greatest part of manufacturing cost. In fact, the two cases presented here, GeLP and GeHP, are in our opinion, the two extreme possibilities between which we may classify, from the economical viewpoint the greatest majority of the semiconductor devices actually produced. We did not take into consideration here, the investment for the general services because that is a function of the size of plant and of climatic conditions which cannot be generalised. Moreover, the possible higher cost of installation in HUC may be compensated by the lower cost of less automatic equipment and of maintenance.

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Agenda Item: D. 7. 1

United Kingdom

A NEW CONCEPT OF A LOW COST INTEGRATED STEELWORKS FOR EMERGENT COUNTRIES

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A NEW CONCEPT OF A LOW COST INTEGRATED STEELWORKS

FOR EMERGENT COUNTRIES

by

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INTRODUCTION

1. The numerous processes by which iron ore may be converted to any of a wide range of steels must necessarily be matched to particular conditions at the steelworks site. In this Paper the special needs of an emergent country which is establishing ab initio a steel industry have been examined. To give verisimilitude to this study, conditions have been assumed which often arise in practice; amongst the most important of these is that capital expenditure is reduced to a minimum. On the basis of assumptions, which are listed in Appendix I, a complete integrated steelworks has been designed which can produce an output of 100,000 tonnes of billet per year.

2. At the start of this design, it was necessary to understand clearly the present and future needs of an emergent country starting to produce its own steel. It would have been possible to propose a list of ingenious but commercially unproven methods of iron and steel making, the inventors of which claim substantial cost reductions, but it is our firm belief that an emergent country should not be saddled with the doubts and teething troubles which inevitably accompany these ideas when they are first applied. The older proven methods meanwhile grow in refinement under the continual economic pressure for greater output and higher efficiency. Perhaps the greatest virtue of the new ideas lies in their catalytic effect on the improvement of the older methods. The study has shown that providing the steelworks for an emergent country is tackled as an integrated design, a small works can be built which uses the basic constituents of the most modern commercially accepted iron and steel making practice with complete freedom for future expansion and refinement at a cost of about £90 ($250) per annual billet tonne. Whilst this figure is substantially less than for some recently built works of more than ten times the capacity, it must be realised that direct comparison is not valid since location, product requirements and in-built expansion capacity must be taken into account. Later in this Paper an attempt has been made to eliminate these factors and it has been shown that the capital cost per tonne of billet on the proposed small scale plant is 1.4 times the capital cost per tonne of billet resulting from an equivalent million tonne per year plant. This is regarded as a highly favourable capital cost ratio and has been achieved by simplification and by the increased use of manual labour on the small scale works to a degree which would not be possible with large scale operation. Inevitably the plant simplification has also resulted in some loss of operating efficiency on the small scale works.

3. Since the emergent countries have no readily available experience on which to draw, all equipment must be of the highest reliability and be capable of operation by unskilled workmen. Complete simplicity has therefore been a keyword in working for this. Designs - in particular the prestressed mill described - have been evolved which not only have a place in small low cost steelworks but which may be expected to make a profound impression in all future construction. Generally, electronic control gear has been omitted in favour of the use of some extra labour, but there is no reason why this refinement should not be added later should economics dictate.

4. A small steelworks of the kind proposed will be most needed in countries commencing a stage of economic expansion. The greatest demand is therefore likely to be for construction materials - that is, reinforcing bar, small structural sections, hexagons, squares, rounds and flats. The layout illustrated may however easily be extended to produce wire or at the other end of the scale, larger joists, channels and rails. Furthermore, by installing an electric melting furnace and a cogging press, suitable small outputs of alloy steels could be made. In spite of the simplicity of the equipment proposed, there is no reason why the quality of the product need be inferior to that from larger and more lavish steelworks producing a similar product.

5. Good coking coals are seldom readily available. It has therefore been assumed that in the basic plant a native low grade coke will be brought into the works from a local supply. If, as seems likely, there is no market for the by-products of coke-making, this supply could be produced by mechanised or, under some circumstances, simple beehive ovens. In some conditions it may be necessary to produce the coke on the steelworks site, and, in this case a mechanised beehive or alternatively a vertical slot coking plant could be built, the latter instead of producing rich gas by the usual regenerative system, would burn this gas internally. The exhaust from the coking plant could then pass to steam boilers and with surplus coke breeze, augment the locally generated electricity supply to a point at which the steelworks could become self-sufficient in generating capacity. This alternative system is envisaged as a possible future addition to the steelworks plant shown in fig. II. In the simple case when coke is brought into the plant from an external supply, there would be enough blast furnace gas to generate electricity in the works for the base load and thus essential services would remain operative and damage be avoided in event of a failure of the outside supply.

6. This study has shown that given reasonable conditions in material supplies, an enterprising emergent country could find ample economic justification for starting a steel industry, even of the very modest capacity discussed.

IRONMAKING

7. Theoretically, the chemical process of extracting iron from its oxides can be accomplished by less fuel than is used in the conventional blast furnace. There is also no reason why the fuel should have the physical properties of metallurgical coke or charcoal. The prospect of using a wide selection of cheap fuels has consequently spurred scientists to seek alternative methods of making iron. Recently more than one workable process has been developed but as yet these present no real challenge to the blast furnace except when unusual conditions tilt the balance in their favour. Typically they would flourish where coking coal or charcoal is unobtainable; where there is abundant cheap electricity; where there is natural gas at negligible cost or where special ore impurities occur or even where production requirements are too small for a blast furnace of economical size. These direct reduction processes must neither be disregarded, nor must there be an attempt to transplant them into an environment to which they are not suited.

8. Although the sense of converting coal to electricity at some 30% efficiency in order to supply heat to an electric reduction process may be elusive, if industry were concerned only with the isolation of iron from its oxide, by laboratory standards some direct reduction processes might prove the most efficient. But the issue is not so simple. In an integrated steelworks, modern methods of steelmaking use iron in the molten state; oxygen blown converters want hot metal with built-in fuel (carbon and silicon); regularity of supply and uniformity of analysis is needed. It is precisely these things that the blast furnace can provide. The suggestion that the carbon balance in the blast furnace is wasteful because fuel is used to bring the product to a liquid state and because the waste gases contain much of the fuel's energy, fails completely when the next stage of the integrated works demands that the metal must be molten and every heat unit in the waste gases is used to good purpose elsewhere in the works. Even slag, unlike gangue from some direct reduction processes, can be an asset as a by-product.

9. Other features stand to the credit of the blast furnace; it can feed upon almost any iron bearing materials; its construction can be simplified to a primitive form or elaborated to the last degree of automation; it requires no rare skill to operate, though skill must be acquired to achieve the best results.

10. Fuel may rightly be regarded as the key to the situation. Preferentially the blast furnace requires coke with a shatter index of about 90%. Nevertheless it remains a fact that a great deal of iron is made, especially in medium sized furnaces with coke of shatter index as low as 65%. Indeed charcoal can be used with advantage in moderate sized furnaces and even coal has been used in some districts, but it would be essential that it had certain coking propensities to prevent disintegration when carbonised in the furnace shaft. Recent innovations, in particular artificial

raising of the gas pressure, have gone far to overcome the irregularities of operation attributable to inferior coke. Likewise a significant proportion of the coke charge may be substituted by oil, gas or pulverized coal injected into the tuyere zone. Finally experiment may prove it possible to carbonise and briquette a local non-coking coal to provide a suitable furnace burden.

11. Beyond all doubt the orthodox blast furnace must be selected as the proven and reliable means of iron making for the emergent country with normal rather than unique conditions. Men of enterprise intent on establishing iron making in a new area, will not expect the chosen spot to be endowed with all the ingredients for success but they would be venturesome indeed if they put their faith in an experimental process rather than following the example of informed opinion throughout the world.

General description of plant

12. Fortunately a blast furnace is not seriously penalised by a restriction on initial capital expenditure. Basic plans can leave provision for all the elaborations which increased output and efficiency may demand whilst providing a furnace which may be simply and reliably operated from the start.

13. One important step in this direction would be to forego any attempt at ore beneficiation. Indeed the economics of attempting sintering, for example, on such a small scale are clearly shown in fig. I which gives the relationship between capital cost and processed quantity for a simple sinter plant. If the installation of beneficiation plant were postponed until the expansion of the steelworks gave economic justification, the exact requirements could be more accurately gauged. Meanwhile the furnace could quite well be charged with run of the mine material until the time was ripe for further investment.

14. With the advent of modern reliable refractories and gas cleaning, a major saving can be made by having two rather than three hot blast stoves. The precaution of holding a third stove in reserve because of occasional fouling of the brickwork by dirty gas is no longer justifiable since the associated risks have receded almost to vanishing point. These two stoves could raise the blast temperature to 800-850°C which is more than needed prior to the introduction of other refinements. The installation of a third stove at a later date would not only allow for the highest conceivable temperature to be reached but could also serve in a battery of five stoves supplying two furnaces, should a second become necessary.

15. For a long time it has been usual to equip a modern blast furnace with automatic means to screen, weigh and charge coke. The furnace proposed however would be of ample dimensions and would start by operating well within its capacity; thus the coke, like other materials, could be charged by the scale car. Automatic equipment would be fitted only when there was a greater demand for output. Following the same policy, the installation of equipment for high top-pressure operation and automatic stove changing would be delayed. Other refinements to follow later would be a passenger elevator to the furnace platform, mechanical slag notch stopper and power operated snort valve.

16. With an output of 100,000 tonnes of billet per year the amount of pig-iron required per day would be about 280 tonnes. However, occasional short duration stoppages of any furnace are possible in addition to the time required periodically for relining. Therefore the nominal rating of the furnace would be set at 320 tonnes of iron per day thus providing a small stock pile of cold iron to tide over operations in the remainder of the plant, or to be sold separately.

17. In its simplest form this furnace would consume about 1¼ tonnes of 22% ash coke per tonne of iron, i.e. 360 tonnes of coke per day. Experience might lead to an increase of driving rate to 400 tonnes per day with a consequent 10% increase in iron output.

18. It is not possible to generalise on the extent to which the furnace would benefit by pre-treatment of the ore, high top pressure, fuel injection, oxygen enrichment and humidification of the blast, but the object would be to reduce the coke consumption per tonne of iron. Thus if the blowing and coke burning rates of the furnace remain constant, the production of iron would increase as the coke per tonne decreased. It is quite conceivable that an apt combination of the above aids would decrease the coke consumption to 0.8 tonnes per tonne of iron, in which case the furnace output would reach almost 500 tonnes of iron per day.

19. Bearing in mind all these future developments, a blower would be needed to deliver 51,000 m^3/hour against 1.4 kg/cm^2 (30,000 c.f.m. against 20 p.s.i.g.) pressure or 42,500 m^3/hour against 1.75 kg/cm^2 (25,000 c.f.m. against 25 p.s.i.g.) pressure. Such a blower, which would be steam driven, could be expected to allow top gas pressure to be raised to between 0.35 and 0.5 kg/cm^2 (5 and 7 p.s.i.g.) at a later stage.

20. To handle an average of approximately 1000 tonnes of raw materials that will arrive daily, a system of furnace bins of one day capacity only would be connected to railway sidings by conveyor belts. Since material supply will essentially be irregular, buffer stockyards are also needed, into which the balance of materials can be fed by a single high line conveyor with throw off positions over the stock-piles. A mechanical shovel can be used both to spread the stock-piles and to feed material into a chute over another conveyor which recirculates it via the main incoming conveyor belt to the furnace bins. The capacity of this inexpensive substitute for the conventional stocking transporter bridge would be sufficient to meet initial requirements on a two shift basis. Three shift operation would later be introduced as the demand for output increased.

21. An electricity propelled scale car would withdraw material from the furnace bins to feed the furnace hoist. Operation of the skip by the scale car driver would be automatically interlocked with the bell opening and closing and distributor rotation to ensure a proper sequence.

22. Iron would be cast five times per day into rail mounted 60 tonne ladles with lids to conserve the heat, and be shunted to the steel melting shop. These ladles are cheaper than the more conventionally used mixers. Surplus iron would be sand cast into pigs or alternatively it could be granulated for easier handling and remelting.

23. It has to be recognised that iron production must temporarily cease after a period for furnace relining. A campaign normally lasts 4 to 10 years, after which the relining process can be completed in three weeks with meticulous planning. This lapse may be used for normal major periodic maintenance of the steel plant or alternatively the flow of production could be continued with stock-piled cold pig and scrap, if available.

STEELMAKING AND CASTING PLANT

24. The choice of steelmaking and casting plant will be substantially influenced by local conditions; nevertheless, two broad classifications exist. The process may be based upon the use of hot blast furnace metal or alternatively, upon steel scrap. Both these terminal conditions have been considered and in the case of the use of molten blast furnace metal, the integrated works has been assumed to operate on a closed scrap balance. Figure III shows the steelworks flow diagram.

25. Steel may be cast either by conventional methods into ingots which are then reduced to billets in a primary mill, or by continuous casting directly to billet size. These alternatives which result in approximately 30% and 16% scrap return respectively, have been compared in conjunction with each steelmaking process. The choice of steelmaking and casting methods must always be based upon both production and capital cost. However, it has been shown below that it is possible to combine low capital cost with an economically realistic production cost.

26. The alternative steelmaking processes using a feed of hot metal are reviewed as follows.

The Bessemer Process

(a) This process is thermally deficient with blast furnace iron of low silicon or phosphorus content and may result in a scrap build-up within the works. Furthermore, an inferior product is obtained which, whilst being suitable for reinforcing bars and small structural sections, could hinder the development of a wider range of products. The use of oxygen steam blast overcomes this problem of quality but a scrap balance could only be maintained by installing an electric melting furnace at extra cost.

The L.D. Process

(b) This method of steelmaking has developed rapidly in recent years because of its simplicity, low capital cost and high production rate. Normally sufficient heat is derived from oxidation to permit the melting of scrap arising from a steelworks based on continuous casting. Modifications such as lime injection allow a wide range of blast furnace metals to be treated. Oxygen is supplied to the converter which, in an integrated works without a piped supply, would be made in tonnage oxygen plant on the site.

The Kaldo Process

(c) This oxygen process is in some ways a more versatile method of steelmaking than the L.D. process. Much of the carbon monoxide is burnt within the converter and this results in high thermal efficiencies. Thus comparatively larger amounts of scrap or ore may be consumed. However, the furnace is mechanically more complex and refractory consumption is higher than in the equivalent L.D. plant.

The Open Hearth Process

(d) This is a most flexible process which accepts a wide range of charge mix. The slow driving rate and heat input affords good metallurgical control. However the furnace units are comparatively large and expensive. Cheap fuel is essential for economic operation and although oxygen can be used to increase output from a given furnace size, the cost of suitable oxygen plant is likely to be at least equivalent to any reductions in capital expenditure achieved on the steelmaking plant.

Comparison of the Processes

27. Within the confines of the assumed emergent conditions, capital and production costs have been worked out for the open hearth, Kaldo and L.D. processes, each operating with the alternatives of continuous casting and conventional casting into 20 cm (8 inch) square ingots. The basis of the comparison has been upon an initial output of 100,000 tonnes per year of cast product and the capital costs shown include all mechanical and electrical equipment, fully erected, together with the necessary ancillaries, i.e. lime kiln, tonnage oxygen plant etc. Services and transport costs are not included since they have been covered in a separate section. Information about the furnaces is shown in Table I.

TABLE I

FURNACE UNITS REQUIRED TO PRODUCE 100,000 TONNES OF CAST PRODUCT PER YEAR

Steelmaking Process	Furnace capacity Tonnes	Average cycle time Minutes	Minimum cycle time Minutes	No. of furnaces installed	Method of operation
Open Hearth (Normal)	60	480	450	2	Both working simultaneously on 84% furnace availability.
L.D.	10	47	25	2	1 working whilst the other is being relined
Kaldo	15	62	45	2	1 working whilst the other is being relined.

28. It is seen that in each case a margin has been left on the theoretical minimum cycle time. This is in order to make an allowance both for future expansion and for the use initially of unskilled labour. A minimum heat size of 10 tonnes has been chosen to give a reasonable production yield per cast and a simplified casting operation.

29. In order that the comparison of the different processes may be based upon similar products, in the case of conventional casting the cost of a primary mill has been included. The results of this comparison investigation are shown in Table II. In making a comparison between the conventional method of using ingot casting with a primary mill, and continuous casting, it must be remembered that the reduction of scrap recirculation from 30% to 16% achieved with continuous casting represents attendant operating cost saving in fuel, power and handling. In addition there is a capital cost saving in furnace size, services and shop space.

TABLE II

COMPARISON OF CAPITAL AND OPERATING COSTS OF ALTERNATIVE STEELMAKING AND CASTING PLANTS

Process	Capital Cost £m	$m	Production Cost shillings/tonne	$ / tonne
Open Hearth + conventional casting + primary mill	2.65	(7.92)	419	59
Open Hearth + continuous casting	2.01	(5.63)	284	40
Kaldo furnace + conventional casting + Primary mill	2.77	(7.75)	412	58
Kaldo furnace + continuous casting	1.62	(4.54)	276	39
L.D. furnace + conventional casting + primary mill	2.63	(7.36)	423	59
L.D. furnace + continuous casting	1.48	(4.14)	282	39

(Production costs include the cost of hot metal but exclude administration and amortisation)

(Capital costs are based on erected buildings and equipment but exclude civil engineering, transport and spares)

Selection of Process

30. The main factor in selecting a suitable steelmaking process for an emergent country must be the initial investment cost. Under the particular conditions chosen, the L.D./Continuous casting combination has been selected and the reasons are shown below.

(a) The combination represents the lowest capital investment per tonne of productive capacity.

(b) The grade of steel required can be produced at low cost with adequate metallurgical control.

(c) The relatively simple expedient of lime blowing enables high phosphorus irons to be treated.

(d) The furnace works on a short cycle producing small quantities of steel regularly. This is particularly desirable for a continuous casting process, producing billets of small cross section.

(e) A closed scrap balance can be maintained.

(f) Refractory consumption is low.

(g) A high yield of saleable product results.

31. Substitution of the primary mill by a continuous casting process is not only a direct cost saving but in addition, the works power plant capacity may be reduced.

Description of plant

32. The layout scheme, fig. II, shows a typical steelmaking and casting plant of this nature to produce 100,000 tonnes per year of 90-120 mm billets (3½ - 4¾ inch). With future widening of the works product range, billets of up to 180 mm (7.1 inch) section may also be cast in the plant described. Only one of the two 10 tonne converters shown would be operated at a given time whilst the second is being relined. The continuous casting plant consists of two single machines each employing a triple mould with space for a third machine. Expansion to 140,000 tonnes per year ou[illegible] can easily be achieved by operating the converters on the minimum cycle time of 32

minutes. In the layout, additional space has been allowed for a third 40 tonne converter which would be needed after the installation of a second blast furnace. The steelmaking and casting plant consists of three bays:- a hot metal and scrap charging bay, furnace bay and the continuous casting bay. There is a separate material stockyard together with adjacent lime kiln and tonnage oxygen plant. Scrap boxes are filled in the mill area and transferred to the melting shop by road and to the converter by crane. The converters are slagged into pots in this bay which is served by a 20 ton ladle crane and a 5 ton scrap charging crane.

33. The furnace and tapping bay contains the two converters, waste gas stacks, lances and control gear. Steel is tapped into a ladle from the furnaces and transferred by car into the continuous casting bay.

34. The continuous casting bay is parallel and adjacent to the furnace tapping bay and is served by a 20 ton high level crane. Steel is teemed via a stopper rod controlled tundish into the water cooled triple mould of the weybridge continuous casting machines. The billets are withdrawn horizontally from the machine on to roller tables where cut-off and parting torches prepare them before delivery to the billet stockyard.

35. A simple raw materials handling system is proposed and the conventional overhead bunker system eliminated. Boxes of the various additions are filled and weighed in an adjacent yard before transfer to the hot metal and scrap bay of the steel plant. From here they are lifted to the converter platform and charged by one of the overhead cranes.

Factors influencing the choice of steelmaking process

36. The choice of steelmaking plant will change if conditions other than those assumed exist. For example, if some quantity of external scrap is available at a favourable cost then careful consideration must be given to the Kaldo and Open Hearth processes. Fuel lances can be used to increase the scrap melting capacity of an L.D. furnace but this must be assessed in the light of the inherent low thermal efficiency of this operation. Such lances would however be used on the proposed plant when the blast furnace is being relined, as during this limited period lower efficiency operation would be acceptable.

STEELMAKING WITH 100% SCRAP

37. In areas where iron ore or suitable coking coal is not present, economical steelmaking is still possible based upon melting, either indigenous or imported scrap. Three alternative processes compete, all of which have a background of successful operation. These are electric arc melting, open hearth and the hot blast cupola converter process. The last two need small additions of cold pig iron charge for successful metallurgical operation but all three processes operate on a wide range of scrap grades. Either Kaldo or L.D. converters may be used with the cupola.

38. Unfortunately no clear guidance can be given on the selection of one of these processes. The choice depends greatly upon the availability and price of electric power, fuel and oxygen. For example, if cheap fuel oil or natural gas is available, then the open hearth process may well be competitive, whilst cheaper electricity obviously favours the electric arc melting method. The yields for the electric arc, open hearth and cupola converter processes are approximately 92%, 90% and 87% respectively. Table III shows typical capital costs for these processes together with the production costs, which it must be recognised may vary substantially under different site conditions.

TABLE III CAPITAL AND PRODUCTION COSTS OF STEELMAKING PLANT BASED ON SCRAP MELTING

	Cupola + L.D. + cont. casting		Cupola + Kaldo + cont. casting		Open Hearth + cont. casting		Electric furnace + cont. casting	
	£m	$ m	£m	$ m	£m	$ m	£m	$ m
Cupola Plant	0.75	2.10	0.75	2.10	-	-	-	-
Steelmaking Plant	0.87	2.44	1.01	2.83	1.2	3.36	0.53	1.48
Casting Equipment	0.67	1.88	0.67	1.88	1.02	2.86	1.02	2.86
Total	2.29	6.42	2.43	6.81	2.22	6.22	1.55	4.34
Production costs per tonne	343/-	$48.0	333/-	$46.6	353/-	$49.4	361/-	$50.5

(Production costs include a charge for scrap metal but exclude administration and amortisation)
(Capital costs are based on erected buildings and equipment but exclude transport and spares)

ROLLING MILL

39. In proposing a mill for an emergent country, the principal objective must be to design a relatively simple mill capable of rolling small quantities of a wide range of products to reasonably close tolerances. At the same time well prepared plans must be laid for future stage by stage expansion. This study of the conditions in an emergent country has shown that a conventional layout can provide an efficient and well-equipped mill which need not depend on highly skilled operators, and yet is well within the probable capital resources of an emergent country.

40. It is appreciated that in addition to the need for reinforcing bar and small sections, there is nearly always a strong demand for galvanised sheet, but this cannot be made as an economical proposition unless the output is considerably larger than practical from a works of this type.

Stage by stage development of the rolling mill

41. A suitable starting point for an emergent country and one on which the cost comparisons in this investigation have been based, would be to install a nine-stand combination bar and light section mill with a capacity of 100,000 billet tonnes per year. This mill would produce rounds, squares and hexagons of 10-15 mm (0.4-0.6 inch) section in straight lengths, as well as 35-75 mm (1.4 - 3.0 inch) angles and up to 75 mm (3.0 inch) channels, joists and flats.

42. In expanding the mill, the first need might well be for coiled rod of 6-10 mm (0.24 - 0.4 inch) section, the smaller size being suitable for wire drawing. At this stage, two-strand rolling could be introduced in the intermediate and finishing stands, which would increase the total output by between 25 and 30%. The smaller sections would then be passed to a six-stand rod mill for further reduction.

43. With growing industry in the country, heavier sections will come into demand. A third stage of development can therefore be contemplated in which a three-stand, three high, medium section mill would roll 15 m. (50 ft.) long channels and beams of up to 175 mm (7 inch) section, as well as 150 mm (6 inch) section angles, rails and fish plates. This addition to rolling capacity would enable the total works' output to match the iron output which might be anticipated from the installation of a second blast furnace. The output of this medium section mill will be so dependent upon programme, that rates cannot be pre-judged accurately in view of the frequent changes and short production runs over a wide range of sizes.

Description of the proposed rolling mill

44. By using a continuous casting process the expense of a breakdown mill has been saved. The billets for the bar mill would therefore arrive in the rolling mill section from the casting machine in 90 or 120 mm ($3\frac{1}{2}$ or $4\frac{1}{2}$ inch) square size of 3 or 5 m. (10 or $16\frac{1}{2}$ ft.) lengths. The medium section mill would accept 120, 150 and 180 mm square billets of the same alternative lengths.

45. Whilst 10 mm (0.4 inch) diameter rods could only be rolled in the proposed mill at a rate of about 12 tonnes per hour, with the sections over 18.5 mm (0.73 inch) the limit on output would be that of furnace capacity - that is 35 tonnes/hour.

46. The billets after dressing and inspection, are charged into a two-zone oil-fired re-heat furnace. Use of end charging and discharging can lead to appreciable cost saving, but it would be necessary to separate the billets manually. An adjustable hydraulic pusher would feed and discharge the billets to the furnace singly.

47. Roughing Stands Billets leaving the furnace area pass to a two-stand, three high roughing mill with roll size 470 mm diameter x 1400 mm long (18.5 x 55 inch). The billet enters the lower roll gap on the first stand and is raised to return in the upper roll gap by an automatic tilting table. It is then returned and positioned in the lower gap by an automatic drop guide. After four passes, the billet is sufficiently small to be guided by repeaters to the second stand.

48. Intermediate Stands From the roughing stands the bar is driven by pinch rolls through a transfer tube. The front and rear ends are trimmed by a photoelectric controlled crop and cobble shear during transfer. Heavier sections which are too big to repeat, are transferred by roller table. The intermediate mills, which for large sections would complete the finishing pass, consist of two 370 mm diameter x 900 mm long (14.6 x 35.4 inch) three-high stands, and one 430 mm x 600 mm long (16.9 x 23.6 inch) two-high stand, each fitted with repeaters for the smaller sections.

49. Bar Finishing Mill Sections below $14\frac{1}{2}$ mm (0.57 inch) are finished in two pairs of 288 mm x 480 mm (11.3 x 18.9 inch) two-high stands fitted with repeaters. A typical rolling schedule is shown for the mill in Table IV.

TABLE IV

TYPICAL ROLLING SCHEDULE

Stand No.	Pass No.	Area sq.mm. (sq.ins.)	Reduction %	Dimensions mm. (ins.)	Length metres (feet)	Speed m/sec. (f/sec.)	Time secs.
-	Billet	8100 (12.55)	-	90 sq. (3.54)	5 (16.4)	-	-
1	1	6340 (9.78)	22	-	6.44 (21.1)	2.6 (8.53)	2.48
1	2	4540 (7.04)	28	-	8.94 (29.3)	2.6 (8.53)	3.44
1	3	3320 (5.14)	27	57.6 sq. (2.26)	12.2 (40.0)	2.6 (8.53)	4.68
1	4	2160 (3.34)	35	-	18.8 (61.6)	2.6 (8.53)	7.23
2	5	1555 (2.41)	28	39.4 sq. (1.55)	26.1 (85.6)	2.6 (8.53)	10
1	6	1025 (1.59)	34	-	39.6 (130)	2.6 (8.53)	15.2
2	7	746 (1.15)	27	27.3 sq. (1.07)	54.4 (178)	2.6 (8.53)	20.9
2	8	522 (0.809)	30	-	78 (256)	2.6 (8.53)	30
3	9	397 (0.615)	24	19.9 sq. (0.78)	102 (334)	3.4 (11.15)	30
3	10	294 (0.456)	26	-	138 (452)	3.4 (11.15)	40.6
4	11	235 (0.364)	20	15.3 sq. (0.60)	173 (567)	3.6 (11.8)	48
4	12	191 (0.296)	19	-	213 (698)	3.6 (11.8)	59
5	13	164 (0.254)	14	14.3 dia. (0.57)	248 (813)	4 (13.1)	62
6	14	132 (0.205)	19	-	308 (1010)	4.9 (16.1)	62
7	15	113 (0.175)	14.7	12.0 dia. (0.47)	359 (1177)	5.6 (18.4)	64
8	16	91.6 (0.142)	18.8	-	442 (1449)	6.9 (22.6)	64
9	17	78.5 (0.122)	14.3	10.0 dia. (0.39)	517 (1695)	7.85 (25.7)	65

Gear ratio for Stands 1 and 2 is 6.8 : 1 with 1200 kW installed power (A.C.)
" " " " 3, 4 and 5 is 3.54 : 1 " 800 kW " " (D.C.)
" " " " 6 and 7 is 2.5 : 1 " 350 kW " " (D.C.)
" " " " 8 and 9 is 1.82 : 1 " 350 kW " " (D.C.)

Note:- The mill motors installed are rated to drive the mills in the first stage of expansion to 140,000 tonnes/year when double stranding would be used. In the event of future expansion not being contemplated, the installed powers could be reduced to 520, 375, 185 and 185 kW respectively to produce 100,000 tonnes/year by single strand rolling.

50. Cooling Bed Finished material from either the intermediate or bar finishing mill is carried to the cooling bed on a high speed roller table fitted with electronically controlled flying shear for cutting to lengths suitable for the 50 m. (164 ft.) bed. At the end of the roller table the bars are pushed off on to a chain conveyor and transferred slowly across stationary skids to be discharged by gravity and collected in batches for shearing to length by a 250 tonne shear. In order that the shear may keep up with production, some multiple cutting will be essential but it is felt that this would be acceptable in order to save initial capital cost.

51. Whilst it is necessary to provide a cooling bed to handle the light merchant sections envisaged, a case may arise where there is a requirement for bar and rod only. Under these circumstances a cheaper solution would be to coil the product. This method, in addition to saving space and thus capital cost, would facilitate marketing of non-standard lengths and also reduce cutting loss to a minimum. The bars would pass through a roll straightener before despatch.

Development to produce small section rod

52. From the bar finishing mill 10 mm (0.4 inch) sizes would be further reduced to 6 mm (0.24 inch) in a six-stand 280 mm diameter x 480 mm long (11.0 x 18.9 inch) rod mill train driven through a multiple gearbox from one motor. With the installation of coilers at this stage, rods up to 30 mm (1.2 inch) diameter could then be coiled on one of four hydraulically stripped pouring reels capable of coiling up to 0.48 tonne. The coils would discharge on to a high speed flat conveyor which would deliver them in the horizontal position to a hook conveyor.

Mill for heavier structural sections

53. The heavier structural sections would be rolled in a medium section mill of two three-high stands 550 mm diameter x 1600 mm long (21.6 x 63.0 inch) and one two-high stand 520 mm x 1000 mm long (20.5 x 39.4 inch).

Pre-stressed stand design

54. The first pre-requisite of accurate tolerance control is a stiff, rigid mill structure. The most economical way of achieving this whilst reducing individual component sizes and weights is to pre-stress the load carrying members. Figures IV, V and VI show a mill design with this feature which has been simplified to the point where it can be fabricated from oxygen-cut steel plate. All three-high stands in the proposed mill area would be of this pre-stressed design, with a fixed middle roll and hydraulically balanced top roll, the top and bottom rolls being adjusted by wedges. The wedges themselves are driven by screws designed to have very small backlash so that the roll adjustment is positive and precise whether the rolls are being lifted or lowered. One advantage of this type of stand is that it permits the use of roller bearings. The stand components are bolted firmly together, giving a minimum of free surfaces in contact, hence mill spring is not increased unnecessarily as components bear down under load. It is felt that these advantages are most relevant in a mill which is to be operated by unskilled crews, since less reliance need be placed on previous experience for setting the proper mill gap to attain a given product thickness. Two-high stands would be designed similarly so as to have identical bearings and chocks, thus leading to simplification of the spares provision. In this case wedge adjustment would be provided on the bottom roll. Both the wedges on any one roll are operated simultaneously by a single screw, which in turn can be adjusted to level the rolls. Axial adjustment is provided by a winged chock and stud arrangement which can be seen in figs. IV and VI.

COMPARISON OF LARGE AND SMALL WORKS

55. In order that a comparison of the costs of the 100,000 tonne works may be made with one of larger output, designs have been prepared and cost analyses made of the three main areas - ironmaking, steelmaking and rolling mill for a plant producing a similar product and of comparable simplified design. With the larger plant it has of course been necessary to modify certain operations to account for the increased output, in particular materials handling equipment where manual and other simplified methods are no longer practical. The 1,000,000 tonne plant includes a medium section mill since this larger output would undoubtedly be reflected by a demand for a wider range of product.

56. The table below shows the cost comparison, based on erected buildings and equipment but excluding civil engineering, transport and spares costs. The ironmaking section excludes furnace blowers which are contained in the power station perimeter.

TABLE V

CAPITAL COST OF 100,000 - 1,000,000 TONNE/YEAR PLANT

	100,000 tonne/year	1,000,000 tonne/year
Ironmaking	£1,205,000	£ 5,600,000
Steelmaking	£1,482,500	£ 6,280,000
Rolling Mills	£1,168,500	£15,819,000
Total -	£3,856,000	£27,699,000

CONCLUSION

57. On the basis of the material and labour costs set out in Appendix IV, it has been shown that a steel plant using a blast furnace for iron making, L.D. converters for steel production, and a pre-stressed merchant bar mill, can produce finished products under the conditions likely to be encountered in an emergent country at a competitive all-in price. Throughout the present study the need has been borne in mind for future expansion, and provision has been made for the progressive increase in the output of the plant up to at least 200,000 billet tonnes per year.

58. It is realised that very wide variations exist in emergent countries' site conditions, and it is evidently impracticable to cover all possible combinations of circumstances in a Paper of moderate length. To simplify matters, the authors have therefore considered a favourable combination of circumstances, which are however not unrepresentative of those found in some countries. The assumptions used in arriving at cost data have been summarised so that those using the information in this Paper can assess its applicability to the particular circumstances with which they are dealing, and make any necessary adjustments.

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APPENDIX I

Summary of assumed material supplies and site conditions

(1) The chosen site is adjacent to a main road and railway, is flat and there is no space restriction.

(2) Soil bearing pressure is 2 tons per sq.ft.

(3) The supply of iron ore from a local site is ungraded but contains no lumps over 20 cms. (8") major dimension.

(4) The ore analysis on a dry basis is as follows:-

Iron	60%	Manganese	0.1%
Silica	0.8%	Phosphorus	0.12%
Alumina	1.8%	Sulphur	0.05%

The raw ore contains 5% moisture.

(5) Dolomite blocks can be delivered to site. No burning plant is necessary.

(6) Sufficient electricity supply is available to supplement works generated power.

(7) There is a township in the district, where living accommodation for employees can be found.

(8) The mean temperature on site will be 25°C. Maximum temperature 45°C, minimum temperature 5°C.

(9) There is sufficient piped supply of settled unfiltered water from a local river which can accept some slightly soiled effluent downstream. Water solids content 25 parts per million.

(10) Coke is available delivered to site of equal or better quality than shown in the following specification:-

Carbon content	76.0%	Ash content	20 - 22%

(11) Limestone to the following specification is available locally:-

Lime	48% (85.7% $CaCO_3$)	Ferric oxide	1%
Magnesia	3% (6.27% $MgCO_3$)	Sulphur dioxide	2%
Alumina	1.5%	Moisture	3.53%

(12) Product specification:-

Carbon	0.1 - 0.15%	Phosphorus	0.06% maximum
Silicon	0.1% maximum	Sulphur	0.06% maximum
Manganese	1.2% maximum		

APPENDIX II

ASSUMED COSTS

Materials	Iron ore	£ 1. 5. 0. per tonne	($ 3.5)
	Boiler oil	£ 8. 10. 0. " "	($ 23.8)
	Coke	£ 4. 17. 6. " "	($ 13.7)
	Scrap	£12. 6. 0. " "	($ 34.5)
	Limestone	£ 1. 6. 0. " "	($ 3.6)
	Burnt dolomite	£10. 11. 0. " "	($ 29.6)
	Electricity	0.8 pence per kWh	($ 0.0093)

Labour Rates

Civil engineering and erection costs have been based on United Kingdom prices. It is felt that this will give a reasonably realistic representation of actual costs for an emergent country where although individuals receive less, this saving is offset by a proportionate increase in the size of the labour force.

Production labour charges have been based on the following wages scales:-

Engineers:	£45 - £135 per month	($126 - $381)
Supervisory staff:	£15 - £50 " "	($42 - $140)
Skilled operators:	5/6 - 15/- per day	($0.8 - $2.1)
Unskilled labour:	3/6 per day	($0.5)

It should be noted that labour charges represent less than 10% of the bare production costs.

APPENDIX III

CAPITAL COSTS

Ironmaking Plant - including:

Blast furnace; refractories; three 60 tonne ladles; concrete bin system; gas cleaning plant; materials handling; plant erection. — Total cost - £1,205,000 ($3,374,000)

Steelmaking Plant - including:

L.D. steelmaking plant; continuous casting plant; lime burning plant; tonnage oxygen plant; refractories; ladles, cars, stands etc.; electrical engineering; buildings; services; erection. — Total cost - £1,482,500 ($4,151,000)

Rolling Mill - including:

Mill mechanical equipment; mill electric drives; buildings; amenities; reheating furnaces; oil storage; cranes for rolling mills and billet stockyard; electricity distribution; cables; lighting; miscellaneous mill operating equipment; roll and guide shop equipment; general maintenance equipment; inter-connecting services and pipe work. — Total cost - £1,168,500 ($3,271,800)

Overall Co-ordinating Services - including:

Site supervision and management; administration block; maintenance shop and stores; laboratory; transport equipment; blast furnace gas and air main; miscellaneous site equipment and services. — Total cost - £1,414,500 ($3,960,600)

Civil Engineering - including:

Site survey; earthmoving and site clearance; boundary wall and gatehouse; roads; railways; drainage; water services; site preparation for the main works areas. — Total cost - £1,364,000 ($3,819,200)

Note:- The above figure is based on the specified flat site conditions and is therefore a minimum cost.

Power Station - including:

Two 36,000 kg/hr. (80,000 lbs/hr) boilers and equipment; two 4,600 kW turbo alternators; two 850 m^3/min. (30,000 c.f.m.) turbo-blowers; water treatment plant; two 25,400 litre/min. (5,600 g.p.m.) cooling water pumps; timber water cooling tower; switchgear, batteries, cables, lighting; substation equipment; buildings. — Total cost - £1,033,500 ($2,893,800)

SUB-TOTAL FOR STEELWORKS

(including - equipment, buildings, erection and co-ordination services) — £7,668,000 ($21,470,400)

Additional estimated capital charges

Spares provision	£700,000	($1,960,000)
Transport (based on 10% of shipped equipment)	£660,000	($1,848,000)

TOTAL CAPITAL COST OF STEELWORKS £9,028,000 ($25,278,400)

APPENDIX IV

PRODUCTION COSTS (excluding administration, amortisation, also credit for gas and slag products)

	100,000 tonnes/year		1,000,000 tonnes/year	
Ironmaking	£ - s - d	£	£ - s - d	£
Ore 1.65 tonnes	2. 1. 3.	5.8	2. 1. 3.	5.8
Coke 1.125 and 0.3 tonnes respectively	3. 9. 8.	15.4	3. 10. 0.	10.9
Flux 0.65 tonnes	16. 4.	2.3	16. 4.	2.3
Labour	9. 6.	1.3	6. 0.	0.8
Maintenance	1. 18. 3.	5.4	1. 15. 0.	4.3
Total per tonne of iron	10. 15. 0.	30.2	8. 16. 7.	24.7
Steelmaking				
Blast furnace metal 0.9107 tonnes	9. 15. 10.	27.4	8. 0. 10.	22.5
Ladle loss 0.0091 tonnes	2. 0.	0.3	2. 0.	0.3
Steel scrap 0.164 tonnes	2. 0. 4.	5.7	2. 0. 4.	5.6
Materials additions	17. 8.	2.5	15. 0.	2.1
Operating & maintenance materials etc.	1. 1. 6.	3.0	13. 6.	1.9
Labour	4. 7.	0.6	3. 6.	0.5
Total per tonne of steel	14. 1. 11.	39.5	11. 15. 2.	33.9
Continuous Casting				
Liquid steel 1.064 tonnes	15. 0. 0.	42.0	12. 10. 3.	35.1
Operating & maintenance materials	12. 8.	1.6	10. 2.	1.4
Labour	1. 11.	0.3	1. 6.	0.2
Sub total	15. 14. 7.	44.1	13. 1. 11.	36.7
Less scrap credit 0.064 tonnes	15. 9.	2.2	15. 9.	2.2
Total per tonne of cast product	14. 18. 10.	41.9	12. 6. 2.	34.5
Rolling				
Billet 1.136 tonnes	16. 19. 6.	47.6	13. 19. 8.	39.2
Production materials	4. 5.	0.6	4. 0.	0.6
Fuel oil	5. 6.	0.8	5. 0.	0.7
Electricity	3. 0.	0.4	2. 6.	0.3
Labour	13. 0.	1.8	10. 0.	1.4
Factory services	4. 0.	0.6	3. 6.	0.5
Maintenance	17. 10.	2.5	15. 0.	2.1
Sub total	19. 7. 3.	54.3	15. 19. 8.	44.8
Less scrap credit 0.13 tonnes	1. 12. 0.	4.5	1. 12. 0.	4.5
Total per tonne of bar and reinforcing rod	17. 15. 3.	49.8	14. 7. 8.	40.3
Works Services				
General works service charge	1. 0. 0.	2.8	17. 6.	2.5
TOTAL PRODUCTION COST FOR BARS AND REINFORCING ROD ETC.	18. 15. 3.	52.6	15. 5. 2.	42.8

Notes:- Costs are based on equal yields for comparison purposes. In practice the larger mill would operate at approximately 92% rather than 88% yield. There would be similar changes in the steelmaking and casting processes, necessitating adjustment of the works mass balance.

APPENDIX V

It will be necessary to make provision for financing material stocks, work in progress, and various debts which might arise in the year following commissioning. A suitable provision would be about 25% of the value of the annual sales. (This figure being based on full output which would not necessarily be achieved in the first year of operation)

Under favourable circumstances the capital costs shown above are representative of the finances necessary to start a steelworks of the type described. Consideration should however be given to the following factors which could increase the capital requirement.

(a) An unlevel, badly drained, poor bearing surface or inaccessible site may appreciably increase civil engineering costs.

(b) It may be necessary to build dock installations to operate the works and a township to accommodate workers.

(c) Connecting links between existing and site road and rail services may be needed.

(d) Water may be in short supply, necessitating extensive and costly cooling, recirculation, and possibly reservoirs and pipelines.

(e) If an electricity supply is not available, some extra generating capacity may be needed to carry peak loads.

(f) There may be customs duties to pay.

(g) Inaccessibility of the site may increase transport costs.

(h) The client may have legal consultancy and management expenses.

(i) There may be a need for operator training and other technical assistance.

(j) All insurance requirements must be considered.

(k) Purchase of site and access wayleaves.

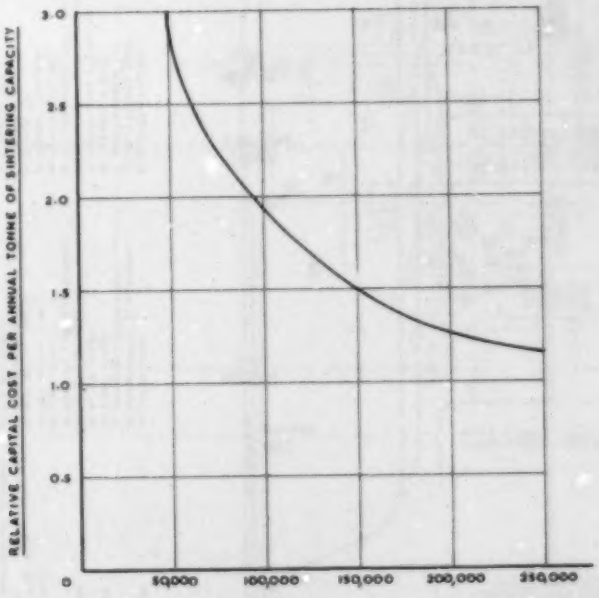
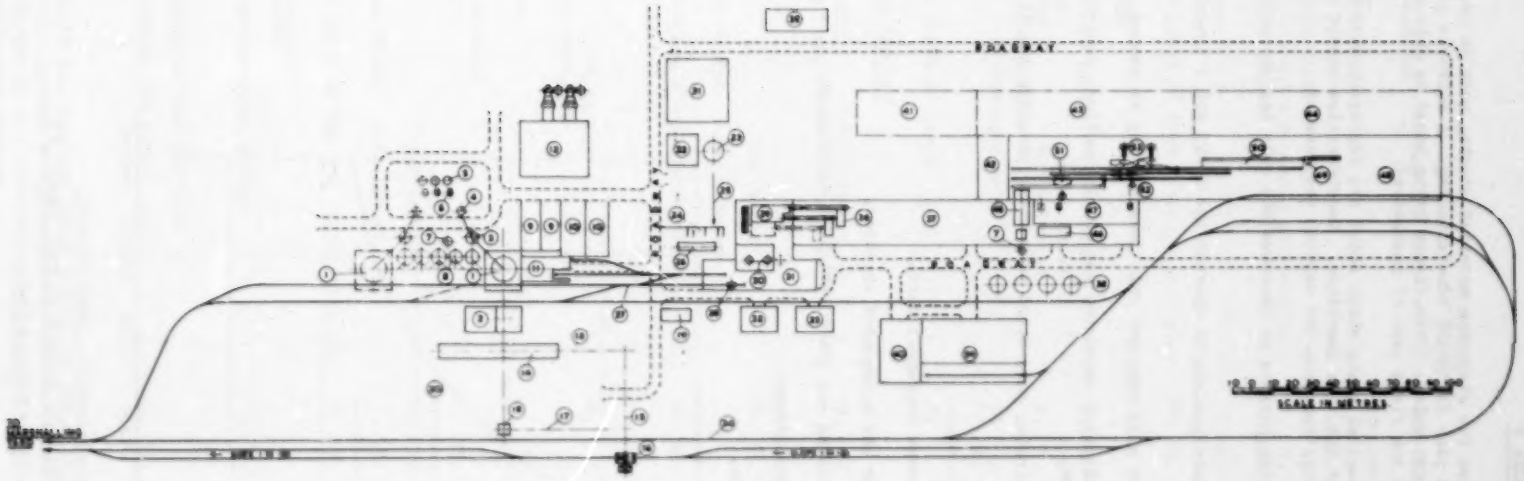


FIG. I THE EFFECT OF SINTER PLANT CAPACITY ON CAPITAL COST.



1. BLAST FURNACE.
2. ENGINE HOUSE.
3. DUSTCATCHER.
4. WASHING TOWER.
5. SEPARATORS.
6. DISINTEGRATORS.
7. CHIMNEYS.
8. STOVES.
9. FURNACE SLAG PITS.
10. MELTING SHOP SLAG PITS.
11. CASTING HOUSE.
12. POWER HOUSE AND FURNACE BLOWERS.
13. SCALE CAR TRACK.
14. HIGH LINE BUNKERS.
15. INCOMING CONVEYOR.
16. WAGON TIPPLER.
17. RECLAIMING CONVEYOR.
18. GROUND HOPPER.
19. LABORATORY.
20. RAW MATERIAL STOCKYARD.
21. INCOMING WATER POND.
22. PUMP HOUSE.
23. WATER TOWER.
24. LIME KILN BUNKERS.
25. RAMP TO LIME KILN BUNKERS.
26. LIME KILN.
27. HOT METAL LINE.
28. HOT METAL LADLE.
29. CONTINUOUS CASTING PLANT.
30. L.D. FURNACES.
31. MELTING SHOP.
32. GAS CLEANING PLANT.
33. OXYGEN PLANT.
34. RUNNING TRACK.
35. ADMINISTRATION BLOCK.
36. COOLING BEDS.
37. BILLET STOCKBAY.
38. OIL STORAGE TANKS.
39. MAINTENANCE SHOP.
40. GENERAL STORES.
41. FUTURE OPEN STOCKYARD.
42. FUTURE FURNACE BAY EXTENSION.
43. FUTURE MEDIUM SECTION BAY.
44. FUTURE COIL BAY.
45. REHEAT FURNACE.
46. SCALE PIT.
47. MOTOR ROOMS.
48. FINISHING BAY.
49. SHEAR.
50. COOLING BED.
51. ROUGHING MILL.
52. INTERMEDIATE MILL.
53. FINISHING MILL.

KEY
PLANT LAYOUT
FUTURE EXTENSIONS
ROADWAYS

FIG. II 100,000 TONNES/ANNUM INTEGRATED STEELWORKS PROPOSED SITE LAYOUT

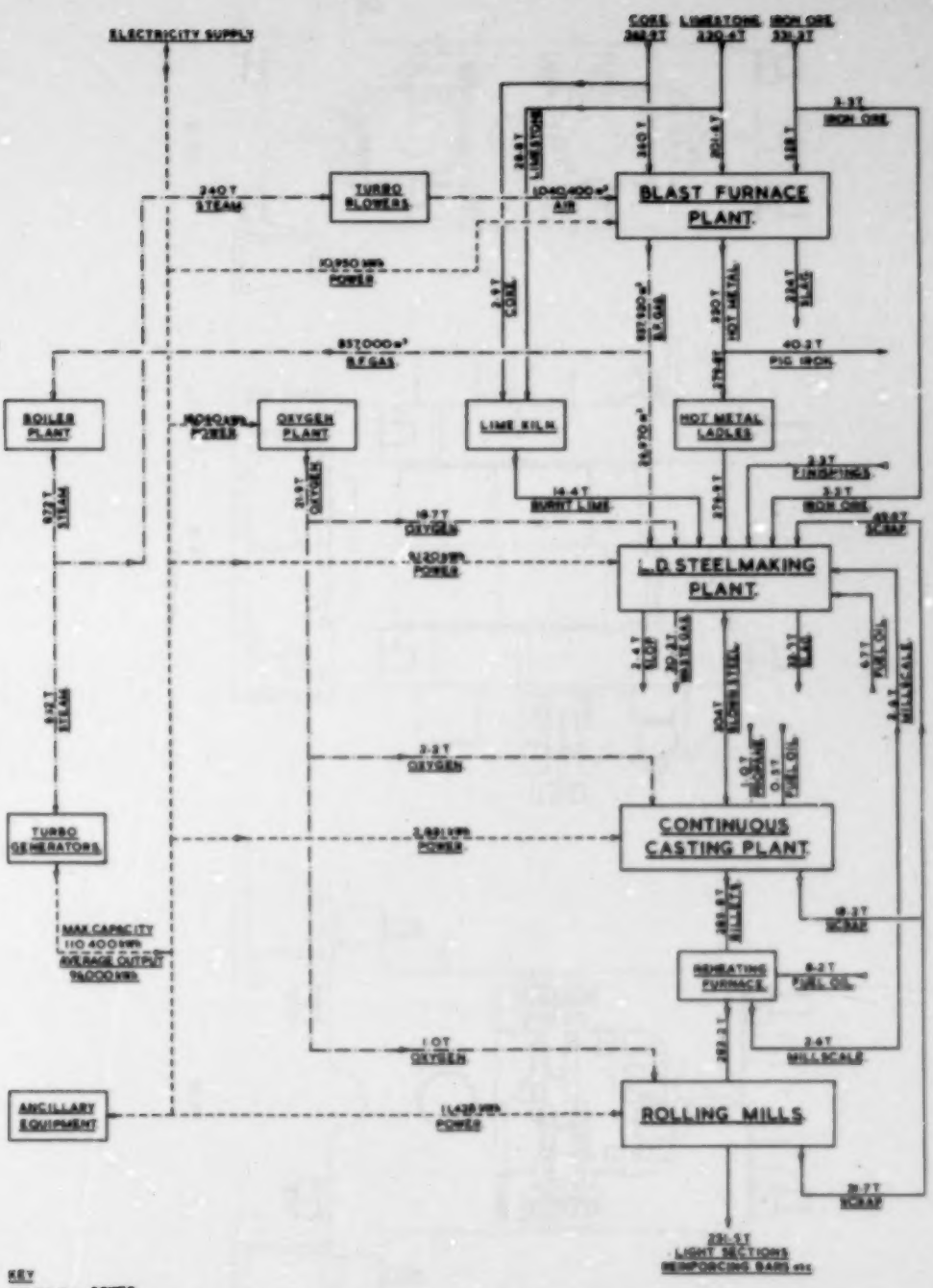


FIG. III FLOW DIAGRAM OF INTEGRATED 100,000 TONNES/ANNUM STEELWORKS. (DAILY BASIS)

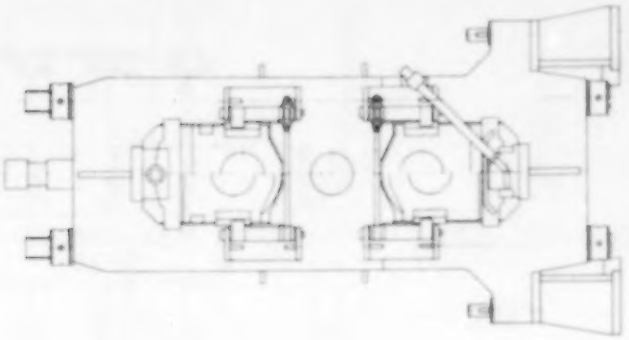


FIG III

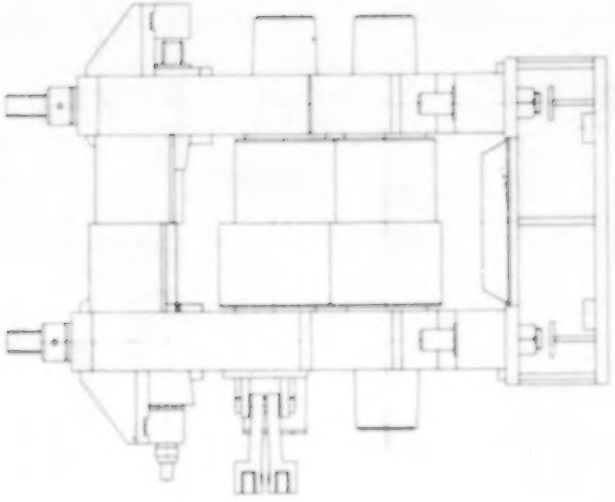


FIG II

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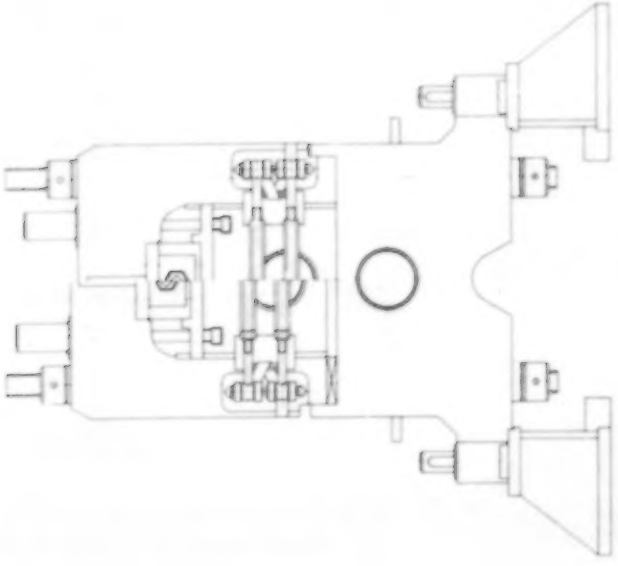

FIG I

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E/CONF.39/D/151
SUMMARY
1 Nov.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

SUMMARY

Agenda Item: D.7.1

United Kingdom

A NEW CONCEPT OF A LOW COST INTEGRATED STEELWORKS FOR EMERGENT COUNTRIES

By G.B.R. FEILDEN, M.A., M.I.Mech.E., F.R.S.,
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Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

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A NEW CONCEPT OF A LOW COST INTEGRATED STEELWORKS FOR EMERGENT COUNTRIES

by

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1. Until recently it has generally been accepted that no integrated steel plant could be economically feasible unless its output were of the order of one million tonnes per year. In order to achieve economical operation at these outputs, the plants were built up of large tonnage producing units incorporating a high degree of mechanical handling, so as to reduce the labour content to a minimum in areas where labour is a high cost factor.

2. The requirement of an emergent country at the start of the development of a steel industry is for a smaller production than one million tonnes in any one plant, and owing to transport difficulties, a number of smaller 100,000 tonne plants producing fairly simple end products are more practical. In these countries labour costs are usually very low, there is a large pool of labour requiring work and plants can be designed to take account of these factors at the same time keeping the capital cost to a minimum, which is important owing to shortage of foreign currency.

3. Investigations into the available raw materials in many such countries indicate that small blast furnaces using indifferent coke can supply the iron, small L.D. converters convert the iron to steel and rolling mills for such products as reinforcing bar, light sections etc., can be designed at a lower capital cost than those currently installed. In this Paper proposals are developed for such installations, which have capital costs appreciably lower than previously published schemes for small integrated steelworks.

4. New methods for the direct reduction of ore to steel were at one time believed to be the solution for steel plants for the emergent countries. As these processes have not yet been tried, except in a few very special circumstances, they are not recommended for the initial operation in an emergent country. In the present proposals, new ground has been cut by the replacement of the primary mills together with their soaking pits and other equipment by the installation of continuous casting machines, the development of which has now reached the point where their installation can be confidently recommended.

5. Site conditions vary widely in areas where small steelworks might be installed. This has necessitated the making of certain assumptions when arriving at cost data in this Paper, but these assumptions have been indicated with a view to enabling those responsible for the formulation of new schemes to assess the particular circumstances applicable in their own cases, in preparation for detailed discussions with their Consulting Engineers and Plant Builders.

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